20TH CENTURY PAINTINGS

Coordinator : P. Cadorin (Switzerland)

Assistant coordinator: D. Giraudy (France)

Members : H. Althöfer (FRG)
G. Berger (USA)
M. Bjarnhof (Denmark)
E. Bosshard (Switzerland)
P. Brambilla Barcilon (Italy)
S. Brans (France)
S. Delbourgo (France)
R. Feller (USA)
I. Gorine (USSR)
W. Hahn (FRG)
R. Hammacher (Belgium)
M. Havel (France)
H. Kühn (FRG)
J. Leymarie (France)
S. Matalon (France)
V. Mehra (Netherlands)
E. Parra (France)
N. Stolow (Canada)

Programme 1978-1981

1. Problèmes posées par la fixation de la couche picturale mâte (Cadorin).
2. Récherches sur la couleur en tant que phénomène esthetique et social (Giraudy).
3. Problèmes de conservation des matériaux organiques et dépérissables (Althöfer).
4. Le cirage de toiles. Traitement (Bjarnhof, Cadorin).
5. Examen - traitement de la peinture mâte chez les peintres suisses: C. Arniet, A. Giacometti et F. Hodler (Bosshard, Cadorin).
6. Problèmes posées par l'enlevement des vernis (Brans).
7. Action des vernis sur la peinture mâte (Feller).
8. L'évolution récente dans l'emploie des nouvelles techniques (Hammacher).
9. Techniques qui provoquent la matité dans la couche picturale (Havel).
10. Phénomènes de dégradation dû au climat (Kühn).
11. Problèmes de la vision de la couleur (Parra).
12. Le dégradation des peintures provoqués par le transport en avion (Stolow).
13. Continuation des recherches sur les techniques de L. Fontana (Brambilla Barcilon, Matalon).
14. L'emploie des matériaux synthétiques dans la peinture actuelle en Extrême Orient et les dégradations inhérentes (Mehra).
15. Analyses des pigments et liants dans la peinture contemporaine: Picasso - Bracque (Delbourgo).

GROUPE DE TRAVAIL PEINTURES DU 20EME SIECLE

Rapport du Coordinateur et programme 1979-1981

Coordinateur: P. Cadorin
Kunstmuseum
St. Albangraben 16
CH-4010 Bâle
Suisse

La principale préoccupation des spécialistes dans la conservation de l'art contemporain provient aujourd'hui de tous les dangers auxquels sont exposées les oeuvres d'art à l'occasion des expositions temporaires. A part les risques communs à toutes le oeuvres d'art lors d'un transport, il est des risques spécifiques à l'oeuvre d'art contemporain: celle-ci en effet se distingue de l'oeuvre du passé par le choix des matériaux employés par l'artiste, souvent moins résistants et par l'emploi de techniques qui rendent l'oeuvre fragile et d'autant plus sensible aux vibrations et aux variations climatiques. Un autre facteur de risque important est d'ordre psychologique: il existe une tendance généralisée à faire moins attention à une oeuvre plus récente: en effet l'opinion commune assimile très souvent les biens culturels à des objets anciens, donc fragiles comme des personnes âgées, tandisqu'elle identifie les créations modernes à la jeunesse donc à la santé! elle s'étonne que ces oeuvres puissent être les objets de tant de soins et n'imagine pas qu'elles puissent déjà avoir besoin de restauration. Si nous considérons que l'art contemporain est en grande partie en possession de l'artiste, du collectionneur ou de la galerie qui le présente, nous ne pouvons pas ignorer les risques de mauvais traitements de l'oeuvre en déplacement, souvent manipulée par des personnes qui n'ont pas une formation professionnelle adéquate.

Mais les moments cruciaux de danger se situent toujours entre le moment du déballage et celui de l'accrochage de l'oeuvre. Le plus souvent, les oeuvres d'art prêtées arrivent à destination dans une atmosphère fébrile d'aménagement des locaux destinés à l'exposition. La présence simultanée d'ouvriers, de divers spécialistes, de préposés aux douanes, d'autres personnes dont la présence n'est pas toujours justifiée, à côté de sceaux de peinture, de tout le matériel de construction qui n'a pas encore été écarté, et de l'inévitable poussière représente des risques certains de dégâts.

De plus, le personnel chargé de la manipulation et de l'accrochage des oeuvres n'a pas toujours les connaissances techniques nécessaires, ce qui représente des risques supplémentaires d'accidents.

Il est par conséquent indispensable d'arriver à défendre l'oeuvre d'art d'une manière plus efficace au moyen d'une information détaillée aux instances responsables des prêts, afin que les recommandations et les avis des spécialistes de la conservation soient suivis et que ne soit pas pris à la légère le risque de détériorer des témoins irremplaçables de nos cultures. Sinon tout le travail de la conservation ne serait plus qu'un pis-aller cherchant à réparer des dégâts qu'on aurait pu éviter et qui souvent sont irrémédiables.

De plus nous déplorons la pratique qui amène à faire subir à l'oeuvre d'art des traitements importants dans le seul but de les rendre aptes à voyager.

Or nous nous trouvons aujourd'hui devant un phénomène de portée mondiale. Partis de la louable intention

de mettre le patrimoine culturel en contact avec un plus grand nombre, les musées ont organisé de plus en plus d'expositions temporaires et vu leur effort couronné par un immense éveil de l'intérêt du public. Ces expositions font aujourd'hui partie intégrante de notre vie culturelle. Cependant, les dommages constatés sur les oeuvres d'art à la suite de ces manifestations ont induit un nombre toujours croissant de collègues à considérer cette activité comme néfaste adoptant parfois une attitude négative vis-à-vis d'actions culturelles de ce genre. Il ne serait pourtant pas réaliste de songer à supprimer ce genre d'activité. Mais il serait possible de la limiter d'une manière raisonnable, en n'encourageant par des prêts que les expositions dont le sérieux et la qualité justifient les dangers auxquels on veut soumettre l'oeuvre d'art en la déplaçant - compte tenu des conditions de sécurité et de conservation guaranties par le requérant.

Puisqu'il incombe aux spécialistes de la conservation de défendre l'intégrité de l'oeuvre d'art, ceux-ci devront prendre les mesures de précaution nécessaires pour réduire au minimum les dangers auxquels peuvent être exposés les biens culturels, et leur mise en garde devra être prise au sérieux s'ils déclarent que l'oeuvre n'est pas en état de supporter un déplacement.

Au cours des nombreuses expositions organisées dans ces dernières années, on a maintes fois dû regretter de graves déficiences dans les procédés d'emballage par exemple, ou la négligence des préposés à la manoeuvre des caisses.

Le grand succès remporté par de nombreuses expositions au cours de ces dernières années, signifie que des foules considérables pénètrent dans les salles où de faibles barrières ne suffisent souvent pas à em-

pêcher les visiteurs de toucher les oeuvres montrées. De plus nous avons constaté à plusieurs reprises lors de visites guidées, que le conférencier voulant dans l'enthousiasme de son exposé indiquer un point précis de l'oeuvre, ne se rend pas compte qu'il touche l'objet de son doigt, ou même de son stylo ou de ses lunettes! Nous connaissons trop de dégâts dûs à ce genre d'activité, et nous prions vivement tous ceux qui sont préposés à la sécurité des oeuvres lors des expositions, de donner des instructions sévères pour éviter ces abus.

Toutefois, une prudence malheureusement justifiée induit de nombreux collègues à exiger la protection de toutes les œuvres prêtées par un verre incassable (ex.: plexiglas), mesure certes défavorable à la perception esthetique, mais efficace dans le but visé.

Nous somme d'avis que toute recherche et toute tentative de restauration d'une oeuvre d'art contemporain ne restera qu'une vaine académie, tant que les régles les plus élémentaires des prévention des dommages ne seront pas respectées.

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Au mois de juillet 1980 eut lieu à Ottawa un Symposium sur les problèmes de la conservation de l'art contemporain, organisé par la Galerie Nationale de cette ville.

L'étendue des sujets examinés, la participation d'un très grand nombre de spécialistes à cette réunion organisée d'une manière impeccable nous ont montré - si

cela était encore nécessaire - le grand intérêt que suscitent les problèmes de la conservation de l'art du XXe siècle.

Pour sa part, notre groupe de travail a pu gagner la collaboration de trois spécialistes dans la conservation de l'art moderne aux Etats Unis:

Madame Jean Volkmer et

Madame Tosca Zagni

qui depuis de nombreuses années dirigent l'atelier de restauration du Museum of Modern Art à New York, ont accepté de nous remettre une contribution sur leur activité, qui sera présentée à Ottawa. D'autrepart,

Madame Margaret Watherston

restauratrice du Whitney Museum of American Art à New York, renommée pour les solutions nouvelles qu'elle a élaborées pour le traitement des tableaux contemporains de grand format nous remettra également une contribution qu'elle illustrera de diapositives pendant la conférence.

Mesdames Pinin Brambilla-Barcilon et Stella Mattalon qui nous avaient communiqué il y a trois ans les résultats de leurs recherches sur la technique de Lucio Fontana, éclaircissent aujourd'hui les problèmes posés par l'oeuvre de l'époque métaphysique de Carlo Carrà, l'un des représentants de la peinture italienne dans la première moitié de ce siècle.

Grâce aux grandes expositions de l'oeuvre de Picasso organisées au cours de ces dernières années, d'importants travaux de recherche ont pu être réalisés sur sa technique.

Madame Suzy Delbourgo, du Laboratoire de Recherche des Musées de France présente l'aperçu d'un

examen approfondi exécuté sur 62 oeuvres de cet artiste. D'autrepart, Mesdames Danièle Giraudy et Monique Veillon et le coordinateur du groupe ont en cours une étude relative au même sujet, dans une approche esthétique, historique et formelle - toujours en relation avec l'évolution de l'oeuvre dans le temps et les problèmes posés par la conservation.

Mesdames Joyce Hill Stoner, 'associate Director' au Winterthur Museum (Delaware USA), et Karen Weiss nous donnent les résultats d'une enquête sur les méthodes de documentation de la technique des artistes contemporains, de même qu'un état de la question aux USA et au Canada: exemples de questionnaires aux artistes, adresses d'institutions et de personnes établissant une documentation de ce genre, bibliographie.

Monsieur François Parra, Directeur adjoint au Museum National d'Histoire Naturelle à Paris, a préparé une contribution sur la vision en relation avec des phénomènes physiques au niveau de l'oeil et de la conscience, et plus particulièrement sous l'influence de certains hallucinogènes.

Monsieur Heinz Althöfer, Directeur du Restaurierungszentrum à Düsseldorf, présente un mémoire sur les applications de l'examen aux rayons-X des oeuvres d'art contemporain, mettant en évidence les difficultés rencontrées lorsque des matériaux hétérogènes et d'épaisseurs différentes obligent à la recherche de nouvelles méthodes d'examen.

Monsieur Edoardo Porta présentera la continuation de ses travaux de recherche sur la peinture espagnole contemporaine, part. la technique de Joan Mirò.

Madame Monique Veillon est présentée comme membre du groupe de travail.

81/6/1

DOCUMENTING CONTEMPORARY ART COLLECTIONS: A SURVEY

Karen Weiss and Joyce Hill Stoner

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: 20th Century Paintings

DOCUMENTING CONTEMPORARY ART COLLECTIONS: A SURVEY

Karen Weiss and Joyce Hill Stoner

Karen Weiss
936 Quail Lane
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USA

Joyce Hill Stoner
Winterthur Museum and Art Conservation Program
University of Delaware
Winterthur, DE 19735
USA

ABSTRACT

At the request of a committee of participants of the 1980 Ottawa conference on The Conservation of Contemporary Art, U.S. museums and conservators have been surveyed to begin a source list of technical information on contemporary art. This may include interviews, questionnaires or any other first-hand documentation regarding materials used, intended appearance or artists' opinions regarding future conservation treatments. Thirty-three institutions or individuals who are compiling data of this nature are identified in the appendix.

In July of 1980, the National Gallery of Canada sponsored an international symposium The Conservation of Contemporary Art. Discussion among the participants focused upon the need for coordinating the efforts of artists, curators, and conservators. Sample interviews with artists presented at the meeting included such diverse media as fiber and film as well as traditional art forms. This survey, however, has investigated collections primarily of paintings to determine what exhibitors are doing to document the artists' materials and methods.

At the symposium information was requested regarding individuals or institutions who might be collecting technical data on contemporary artists or specific works. An announcement to this effect was placed in the September issue of the American Association of Museum's Aviso and the August American Institute for Conservation Newsletter; and a letter was sent to one hundred museums throughout the United States and Canada, which were identified by the Museum Directory as either having a permanent collection or regularly exhibiting contemporary art. It is hoped that a similar survey will soon be carried out overseas.

There were twenty-three respondents of which eight indicated that no technical records are kept. Several of these cite understaffing and lack of funds; several institutions have not considered the need for such information but would appreciate being provided guidelines for establishing such a system. The second third of respondents keep some records; usually the medium is identified as part of the accession data. In several instances the information may be present for some works and not for others; correspondence

with the artist and exhibition catalogues may coincidentally contain technical information. Instances have occurred when the artist has been contacted to advise what conservation measures should be taken. In regard to special exhibitions, curators who commented on this aspect of the problem indicate that they honor expressed directions accompanying the work, but there is no concerted effort to compile any data for future reference.

The Western Association for Art Conservators (WAAC) has prepared a form to be provided to the artist (see Appendix 1) whose responsibility it is to attach the information to the painting. So far this project is in an experimental stage with no major funding to continue on a major scale. Artists have been informed of this form only if they have had contacts within the organization. No registry has yet been planned.

The basic information required by one museum's accession files includes the media, the dimensions, and the support. Three respondents (in addition to the WAAC) request very specific information such as trade names and special formulae (see Appendix 2). Additional data include method of fabrication, storage requirements, routine maintenance, and special installation. Other information on these forms is of greater significance to the art historian than to the conservator. Currently no respondents are utilizing an automated information retrieval system, although two museums expect to have a computerized system within three years. Three museums identified at the conference as maintaining such files about their collections did not reply.

On a national scale the Archives of American Art gathers material on artists and collections. The collection was established for the purpose of promoting "scholarship by acquiring and preserving the basic documentary source materials needed for the study of American art and to make these materials easily available to scholars working in this country and throughout the world." Under the auspices of the Smithsonian Institution since 1970, there are now five regional offices:

New York Area Center and Office of the Director
41 East 65th Street
New York, New York 10021

Washington Area Center
NCFA-NPG Building
8th and F Streets, N.W.
Washington, D.C. 20560

Midwest Area Center
5200 Woodward Avenue
Detroit, Michigan 48202

New England Area Center
87 Mount Vernon Street
Boston, Massachusetts 02108

West Coast Area Center
M. H. de Young Memorial Museum
Golden Gate Park
San Francisco, California 94118.

Contained on microfilm rolls available through interlibrary loan are: correspondence, journals, notes, business records, sketchbooks, photographs, tape-recorded interviews, press clippings, magazine articles, art auction and exhibition catalogs. The microfilm is to be used in the borrowing library; some items are only available at the regional offices. In regard to certain restricted items, the researcher must secure permission from the artist or his/her heir. A number of publications have been published by the Archives of American Art to facilitate use of this collection (see Appendix 3).

Besides the Archives of American Art, the General Services Administration under the direction of Donald W. Thalacker is compiling a file on each public "artwork" which has been commissioned by the Art-in-Architecture Program. The documents will be filed in Washington, D.C., in the regional office having jurisdiction over the particular building, and in the individual Building Manager's office. The goal of this program is to have available the necessary information to care for, maintain, and conserve the artwork.

A number of directories have been published that may prove useful in documenting contemporary art works. These tests contain bibliographical information which may provide some technical information. Based upon interviews done for the Archives of American Art, Paul Cummings has published a book of interviews with twelve twentieth century artists. On the continent, Erich Gantzert-Castrillo has published a similar but more extensive text: Archiv für Techniken und Arbeitsmaterialien Zeitgenössicher Künstler (Wiesbaden: Museum Wiesbaden Harlekin Art, 1979). By researching individual artists, it may be possible to find a book such as Helen Frankenthaler Prints: 1961-1979 to be helpful. For a brief listing of directories of contemporary North American artists, see Appendix 4.

A number of individuals and institutions have also been involved in documenting contemporary artworks or artists (see Appendix 5 for a full listing). There is definitely interest in this area, and private conservators and museums see the need for this type of documentation. However, to establish a cooperative attitude among artists, curators, and conservators to facilitate this documentation will require a great deal of expertise and administration from a central coordinating body which has not yet assumed this role. For the time being, efforts will have to be directed in maintaining updated lists of those who are involved in this work, and such information should ideally be available to those who need it.

APPENDIX 1

IMPORTANT TECHNICAL DATA · KEEP WITH ARTWORK
MAY ASSIST CONSERVATORS IN CASE OF DAMAGE OR FUTURE CLEANING

ARTIST: DATE:

TITLE: I.D.#:

DIMENSIONS:

MATERIALS AND METHODS (BRAND NAMES, FORMULATIONS, ETC.)

SUPPORT: SURFACE COATING/VARNISH:

PRIMING:

GROUND:

DESIGN LAYER: MEDIA/ADHESIVES/ETC.

DESIRED FINISH
☐ NONE ☐ SEMIGLOSS
☐ MATTE ☐ GLOSS

western association waac of art conservators

THIS INFORMATION HAS BEEN PROVIDED BY THE ARTIST IN COOPERATION WITH THE WESTERN ASSOCIATION OF ART CONSERVATORS 5905 WILSHIRE BLVD. LOS ANGELES, CA. 90036 (213) 937-4250

CAUTION: DO NOT AFFIX TO REVERSE OF ORIGINAL FABRIC OR PAPER

APPENDIX 2

Documentation Forms Received

Walker Art Center
Vineland Place
Minneapolis, Minnesota 55403

Title of work (Is it correct?) ______________________
Medium of work (Is it correct?) ______________________
Date executed ______________________
Place executed ______________________

Technical methods: As an aid in handling, conservation and restoration, please describe the technical processes used in the creation of the work. If possible, give exact information regarding any of the following which apply to this work, adding all other pertinent information: material (including trade names), fabrication (company, method, etc.), support, suggested storage requirements, suggested routine maintenance and special installation requirements.

Where and when was this work exhibited before the Art Center acquired it?

Will you kindly give us information about the subject of this work, the ideas expressed in it, the circumstances under which it was executed, any comments you would like to make on it, or any other information which would be of interest in the future.

____
Date

____
Signature

MUSEUM OF CONTEMPORARY ART
237 East Ontario Street
Chicago, Illinois 60611

Title of work (please correct, if necessary):
Date executed (please be as exact as possible):
Place executed:
Materials and Technique:
In order to insure that the condition of your work is maintained according to the highest standards, please describe as precisely as possible the materials and fabrication techniques used in this piece. Whenever possible, please include trade names, name of fabrication company, etc.

Installation:
Please note any special instructions regarding the installation or hanging of this piece. Provide a diagram if necessary.

Exhibition History:
Where and when was this work exhibited before it became part of the Museum of Contemporary Art Permanent Collection?

Publication History:
Where and when was this work reproduced or mentioned in print before it became part of the Museum of Contemporary Art Permanent Collection?

We would appreciate any comments on the subject of this work, its title, the ideas in it, the circumstances under which it was executed, your intentions in making it, or any additional remarks you would like to make.

BURNABY ART GALLERY ACC.NO. ____________
(6344 Gilpin St., Burnaby, B.C. V5G 2J3)
ARTIST ________________________ ORIGIN ____________
TITLE ____
MEDIA ____
SIZE. H ___ W ___ IMP. H ___ W ___ PAPER. H ___ W ___ OTHER ___
ACQUISITION ____
PRICE ________________ INS. VALUE ________________
SIGNED. YES _____ NO _______ LOCATION ________________
DATES. YES _____ NO _______ LOCATION ________________
COMMENTS ____

GSA ART-IN-ARCHITECTURE ARTIST'S QUESTIONNAIRE

Artist:
Title of work:
Completion date:
Location:
Dimensions: height x width x depth in feet and inches
Weight:
Construction, composition of the work (for the following, please use dates, methods, and products used):

1. Materials (kind, variety, quality, preparatory work, joining of blocks, hollowing out, etc.).
2. Medium or construction (description of assemblages, materials, and methods).

GSA ART-IN-ARCHITECTURE ARTIST'S QUESTIONNAIRE - Continued

Support:
Medium:
Ground (preparation of surface before painting, etc.; adhesion, cohesion):
Paint layer:
Surface coating (finished layer):

3. General recommendations for care and maintenance:

THE BROOKLYN MUSEUM
188 Eastern Parkway
Brooklyn, New York 11238

Painting Record
Department of Paintings and Sculpture

Artist:
Title of work:
Date: Place executed:
Medium (please list types of paint, manufacturers, and number of paint layers if structure is complex; be as fully descriptive as possible):
Support:
canvas...............; cotton duck.........; other..................
preprimed.............; unprimed............; primed by artist(please list materials used, manufacturer, and number of layers): ....

Please indicate if this painting is varnished (partially? entirely?):

Name of varnish used:

If any special techniques were employed in the making of this work, please describe the materials and methods used:

Are there any special instructions for the installation or maintenance of this work:

If appropriate, please discuss title:

Is there any documentation you care to provide on the personal, social or symbolic reference in this work:

[Please Turn Over]

Are there any exceptional circumstances or incidents that relate to the making of this work or its subsequent history?

If there are studies or preliminary drawings for this work, or if this is a study for another work, please indicate titles of these related works and collections:

Place and date this work first publicly shown:

Place and dates of subsequent exhibitions:

Through whom was if first sold?
Previous collections (also include private individuals to whom work has been lent, eg. another artist):
Where has this work been published, reproduced, discussed, or mentioned?
Have you written about the work (include published and unpublished material)?

[The sculpture record also contains the same last eleven questions beginning with "Are there any special instructions for the installation...

THE BROOKLYN MUSEUM
188 Eastern Parkway
Brooklyn, New York 11238

Sculpture Record ____________
Department of Paintings and Sculpture

Artist:
Title of work:
Date: Place executed:
Medium (as fully descriptive as possible):

If a cast or commercially fabricated work, please indicate
foundry or factory:
number of this cast, total number in edition:
in what collections are other casts?

If the process of making this work is of special interest, the Museum would like a description:

APPENDIX 3

Reference Material for Using the Collections of the Archives of American Art

ARCHIVES OF AMERICAN ART: A CHECKLIST OF THE COLLECTION
Washington: Smithsonian Institution, 2nd Ed., Rev., 1977.

THE ARCHIVES OF AMERICAN ART: COLLECTION OF EXHIBITION CATALOGS
Boston: G. K. Hall and Company, 1979.

ARCHIVES OF AMERICAN ART. JOURNAL.

McCoy, Garnett, ARCHIVES OF AMERICAN ART: A DIRECTORY OF RESOURCES
New York: Bowker, 1972.

Spiegel, Ruth W., Ed., ARTS IN AMERICA: A BIBLIOGRAPHY
Washington: Published for Archives of American Art by Smithsonian Institution Press, 1979.

APPENDIX 4

Bibliography for Documentation: Contemporary North American Artists

Cederholm, Theresa Dickason. AFRO-AMERICAN ARTISTS: A BIO-BIBLIOGRAPHICAL DIRECTORY. Boston: Trustees of the Boston Public Library, 1973.

Cummings, Paul. ARTISTS IN THEIR OWN WORDS. New York: St. Martin's Press, 1979.

Cummings, Paul. DICTIONARY OF CONTEMPORARY AMERICAN ARTISTS. New York: St. Martin's Press, 1977.

Hill, Vicki Lynn, Project Coordinator. FEMALE ARTISTS PAST AND PRESENT. Berkeley: Women's History Research Center, Inc., 1974.

MacDonald, Colin, S., Compiler. A DICTIONARY OF CANADIAN ARTISTS. Ottawa, Canadian Paperbacks (1967).

Press, Jacques Cattell, Ed. WHO'S WHO IN AMERICAN ART 1980. New York and London: R. R. Bowker Company, 1980.

REGISTER OF UNITED STATES LIVING ARTISTS.

APPENDIX 5

Resources: Documenting Contemporary Artworks

Appendixes 4 and 5 provide published sources of information regarding artists and collections. The following list identifies individuals, institutes and museums which have information which may be useful in the preservation of contemporary artworks. The list is alphabetical by country, state or province within country, and by party to be contacted if an individual's name is available. A brief description of the work done by the party is provided.

CANADA

Beattie, Brent
Head Preparator
Burnaby Art Gallery
6344 Gilpin Street
Burnaby, British Columbia
Canada V5G 2J3

Three cards are prepared for each work in the permanent collection: the media is specified. Technical information on materials, method and intention is not indicated unless requested by artist.

Barclay, Marion H., Conservator
National Gallery of Canada
Restoration and Conservation Lab
Ottawa, Ontario
Canada K1A OM8

International Symposium on the Conservation of Contemporary Art; July 7-12, 1980; Ottawa. "A Stabilizing Treatment for a Contemporary Three Hundred-Pound Oil Painting on Canvas," Abs. p.19. Discusses Saturn by Milton Resnick. "National Gallery of Canada Questionnaires to Artists: The Old and New Formats," Abs. p.39.

Vogel, Peter, Chief
Fine Art and Polychromes Lab
Canadian Conservation Institute
Ottawa, Ontario
Canada

International Symposium...; July 7-12, 1980; Ottawa. "Conservation of High Impasto Paintings," Abs. p.20. Includes case histories with Canadian artists.

Cummings, Lynn
134½ Hunter Street, W., Apt. 9
Peterborough, Ontario
Canada

It Is not a Trend; It is an Inevitability...Interviews with Nine Contemporary Artists. Ottawa; National Gallery of Canada, n.d. Interviews with Richard Buff, Dorothy Caldwell, Jennifer Dickson, Vera Frenkel, David Hlynsky, Denise Ireland, Suzy Lake, Jane Martin and Paul Wong.

GREAT BRITAIN

Leback-Sitwell, C., Conservator
The Tate Gallery
Millbank
London SW1P 4GR
England

International Symposium...; July 7-12, 1980; Ottawa. "Materials and Techniques of British Artists Since 1943," Abs. p.39. Includes artists' experiences with materials and their techniques.

Wilson, Peter and Nairne, Sandy The Tate Gallery Millbank London SW1P 4RG	International Symposium...; July 7-12, 1980; Ottawa. "The Installation File-Conserving by Documenting," Abs. p.16.

GERMANY

Althöfer, Heinz, Direktor Henkel Foundation Centre for the Conservation of Modern Art Dusseldorf, Germany	Documenting Technology.
Nuremberg Institute for Modern Art Nuremberg, Germany	A file on contemporary artists of international recognition, but technical information not readily accessible.
Gantzert-Castrillo, Erich Wiesbaden Museum Archive for Contemporary Artists' Techniques Wiesbaden, Germany	Archiv fur Techniken und Arbeitsmaterialien zeitgenossicher Kunstler. Wiesbaden: Museum Wiesbaden Harlekin Art, 1979.

SWITZERLAND

Cadorin, Paolo Chief Conservator Basel Kunstmuseum, Switzerland	Coordinator of the ICOM Committee for Conservation Working Group on the Conservation of Contemporary Art.
von Imhoff, H.C., Head Conservation Training Programme Art and Craft Technical College Berne, Switzerland	International Symposium...; July 7-12, 1980; Ottawa. "Documentation of Artists' Materials and Techniques," Abs. p.37.
Bosshard, Emil Swiss Institute for Art Research Postbox 8024 Zurich, Switzerland	Documentation.

UNITED STATES

Whitworth, Ilene, Registrar Montgomery Museum of Fine Arts 440 South McDonough Street Montgomery, Alabama 36104	Each painting has three cards: catalogue card, artist's card, and medium card. Media identified on all 3 cards. An artist's file contains biographical data and list of exhibitions.
Smith, Kent, Assistant Curator Long Beach Museum of Art 2300 East Ocen Boulevard Long Beach, California 90803	The permanent collection files contain articles, announcements, catalogues, and acquisition correspondence on each artist. For restoration the artist is consulted who does work or recommends conservator.

Blythe, Victoria Western Association of Art Conservators c/o Los Angeles County Museum of Art 5905 Wilshire Boulevard Los Angeles, California 90036	Contact for WAAC and its documentation program. Paper conservator married to contemporary artist.
Domergue, Denise 263 South Alexandria Avenue Los Angeles, California 90004	International Symposium...; July 7-12, 1980; Ottawa. "Contemporary Paintings: A Sample of Artists' Methods and Conservators' Constraints," Abs. p.25. Includes work on paintings by Sam Francis, Claire Falkenstein, Ed Ruscha, Ed Moses, et al.
Leisher, William R. Head of Conservation Los Angeles County Museum of Art 5905 Wilshire Boulevard Los Angeles, Calfornia 90036	Available data obtained as pertinent; no formalized procedure.
Druzik, James, Conservator Norton Simon Museum Colorado and Orange Grove Blvds. Pasadena, California 91105	For conservation work a painting is returned to the artist or is sent to the Los Angeles County Museum of Art for treatment; no formal records.
San Francisco Museum of Modern Art Van Ness at McAllister San Francisco, California 94102	Identified as maintaining documentation but no response from museum. Conservators Inge-Lise Eckmann and James Bernstein presented "Compensation Techniques for Contemporary Paintings," at the International Symposium...; July 7-12, 1980; Ottawa.
Archives of American Art	See page 2 and Appendix 3.
Stevens, Rebecca A.T. Contemporary Textile Consultant The Textile Museum 2320 S Street, N.W. Washington, D.C. 20008	In regard to loan exhibits artists are consulted about special instructions and display.
Thalacker, Donald W., Director Art-in-Architecture Program General Services Administration Public Buildings Service Washington, D.C. 20405	Registration of public artworks.
Lowitz, Ted, Research Assistant Museum of Contemporary Art 237 East Ontario Street Chicago, Illinois 606111	A Permanent Collections archive file on each painting contains donor or vendor information: materials, techniques, stora care and installation. With a few works which require special handling, preparat and curators rely on memorized instructi In regard to traveling exhibitions, the staff relies upon originating institutio to provide conservation and installation instructions.

Decato, Carolyn Clark, Registrar Walker Art Center Vineland Place Minneapolis, Minnesota 55403	Questionnaire is filled out by artist or representative when the work is accessioned.
Connor, Holly Pyne Assistant Curator The Brooklyn Museum 188 Eastern Parkway Brooklyn, New York 11238	For paintings and sculpture in the permanent collection, a questionnaire is filed by artist and is available to curatorial and conservation staffs.
Schultz, Douglas G. Chief Curator The Albright-Knox Art Gallery 1285 Elmwood Avenue Buffalo, New York 14222	For several contemporary sculptures the type of paint and specific color is kept on records. In several, instances, the artists have been contacted for conservation work.
Franklin Furnace 112 Franklin Street New York, New York 10013	No information available.
Museum of Holography 11 Mercer Street New York, New York	Will provide information on archiving holograms.
Volkmer, Jean The Museum of Modern Art 11 West 53rd Street New York, New York 10019	Personal file on artists' techniques determined through working on the paintings or when informed by artist; filed by artist's name. Museum maintains questionnaires from living artists upon acquisition of work; one question deals with technique; file maintained in the Painting and Sculpture Department.
Brown, Ann Barton Curator of Collections Brandywine River Museum Brandywine Conservancy P. O. Box 141 Chadds Ford, PA 19317	Museum maintains condition reports and conservation reports.
Geyer, Ginger Henry Assistant Registrar Dallas Museum of Fine Arts State Fair opposite Cotton Bowl Dallas, Texas 75226	Curatorial file contains technical data on 33 artists (work on unusual construction). There are specific quotations from artists and dealers; the artists' opinions on care and repair are cited.
Montgomery, Colleen L. Registrar Robert Hull Fleming Museum Colchester Avenue Burlington, Vermont 05405	Artists are contacted for information which is filed by artist, accession number, and name of source. A description of the medium and other information the artist feels pertinent are recorded.

81/6/1-12

Milwaukee Art Center
750 N. Lincoln Memorial Drive
Milwaukee, Wisconsin 53202

Identified as maintaining documentation; no response from museum.

ETUDE DE LA MATIERE PICTURALE DE PABLO PICASSO

Suzy Delbourgo

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981
Groupe de travail: Peintures du 20ème siècle

ETUDE DE LA MATIERE PICTURALE DE PABLO PICASSO

Suzy Delbourgo
Laboratoire de Recherche des Musées de France
Palais du Louvre
75001 Paris
France

SOMMAIRE

Un ensemble de 62 tableaux de Picasso choisis parmi les oeuvres reçues en paiement des droits de succession a été examiné au Laboratoire de Recherche des Musées de France.

Les oeuvres s'échelonnent de 1895 à 1961 et ont été étudiées par les méthodes habituelles des laboratoires de musée : radiographie, photographie sous infra-rouge, et plus particulièrement pour les pigments, spectrométrie de microfluorescence X, et pour les liants, tests sur coupes minces et chromatographie en phase gazeuse.

L'étude en profondeur de ces oeuvres de Picasso a révélé une expression picturale qui conjugue la plus grande maîtrise technique à une excellente qualité des matériaux.

De plus, il s'établit grâce à cette étude une liaison entre l'ordre chronologique des tableaux et l'utilisation des différents pigments.

Enfin l'ensemble des résultats obtenus, encore partiels, constituera une référence analytique objective effectuée sur l'oeuvre de Picasso.

Cette étude a été conduite au Laboratoire de Recherche des Musées de France sur une soixantaine de tableaux faisant partie des oeuvres de Picasso reçues par l'Etat français en dation, c'est à dire en paiement des droits de succession. Cet ensemble prestigieux est destiné à être réuni au Musée Pablo Picasso qui sera installé dans l'Hôtel Salé, situé dans le quartier du Marais à Paris.

Les tableaux choisis pour l'examen scientifique par Dominique Bozo, conservateur de la collection, couvrent dans le temps une large part de l'oeuvre de Picasso, puisqu'ils vont de 1895 avec "La fillette aux pieds nus", peint à l'âge de 14 ans, jusqu'en 1961 avec le "Déjeuner sur l'herbe, d'après Manet" en passant par de nombreuses pièces majeures comme l'"Autoportrait" de 1901, "La flûte de Pan" (1923) et "La Crucifixion" (1930).

Ces oeuvres ont été étudiées au Laboratoire par tous les moyens analytiques, maintenant bien connus, dont il dispose, tant sur le plan de la conception créatrice, à l'aide de méthodes optiques radiographiques et infra-rouges, que sur celui des matériaux utilisés par Picasso, pigments, liants, aussi bien que supports.

Ce sont les premiers résultats obtenus, encore très partiels, qui font l'objet de cette communication. Ils offrent d'ores et déjà une multitude de renseignements sur la technique du peintre, obtenus sur des tableaux importants, sûrs et bien datés. Lorsque l'étude sera terminée, il est évident que la somme des résultats servira de références indiscutables pour des oeuvres moins bien répertoriées, voire inconnues, et pourra fournir le cas échéant des critères objectifs d'authentification.

LA CONCEPTION FORMELLE

Une première partie de l'étude des tableaux de Picasso a comporté des examens radiographiques et infra-rouges sur l'ensemble des oeuvres énumérées dans la liste placée en annexe. Nous ne développerons pas ici les résultats obtenus par ces techniques, mais il faut cependant signaler qu'elles aident largement à suivre l'évolution de la pensée créatrice de l'artiste et de son métier, et apporte un complément non négligeable à l'étude stylistique et historique.

D'une part, les documents ainsi obtenus révèlent sous l'oeuvre achevée l'esquisse première, qui vient ainsi compléter la série des études ou dessins existant par ailleurs et se comparer à elle, nous offrant toutes les étapes successives, invisibles autant que visibles, de la création de l'oeuvre.

L'étude en profondeur des peintures de Picasso révèle sous l'apparente rapidité de l'écriture une lente élaboration faite de recherche et quelquefois de repentirs, parfois visibles comme dans "La nageuse" (1929) ou plus souvent invisibles, révélés par la radiographie. Le beau "Portrait de Marie-Thérèse" (1937) en est un exemple, qui montre les multiples reprises de l'artiste.

D'autre part, l'image radiographique rend évidents, outre les recherches picturales, les procédés de mise en place, le dessin des contours, la qualité de la touche, le maniement de la pâte. Elle souligne encore la virtuosité technique du peintre, et malgré le nombre infini de procédés techniques expérimentés par Picasso, concourt cependant à classer ses différents modes d'expression selon les époques et les sujets traités.

LES SUPPORTS

Une recherche particulière a été menée sur les supports et les toiles dont les caractéristiques techniques ont été rassemblées : grosseur, tissage, enduit de préparation. Dans leur ensemble, les tableaux sont peints sur toile mis à part six d'entre eux. "La mort de Casagemas" (1900), "Corrida : la mort d'un torero" (1933) et "La suppliante" (1937) sont peints sur bois. "La Crucifixion" (1930) et "Massacre en Corée" (1951) sont peints sur contreplaqué, et "Les deux frères" (1906) sur carton.

La toile présente généralement une préparation commerciale au blanc de plomb ou au blanc de zinc, sauf pour deux tableaux peints pendant la guerre sur une toile à drap brute, l'"Homme à la cheminée" (1916) et "Le repas de paysans" (1917-18).

La plupart des tableaux ont reçu au dessus de la préparation commerciale une couche d'impression blanche ou quelquefois foncée qui montre bien le soin apporté par Picasso à préparer son support.

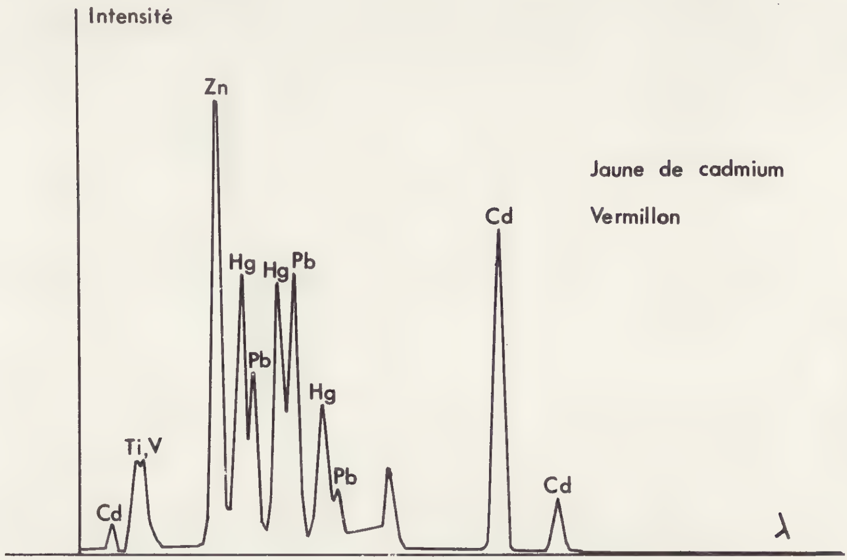
LES PIGMENTS

L'analyse des matériaux, tant celle des pigments que des liants, a été conduite par différentes méthodes physicochimiques dont il était évidemment nécessaire qu'elles soient aussi peu destructives que possible.

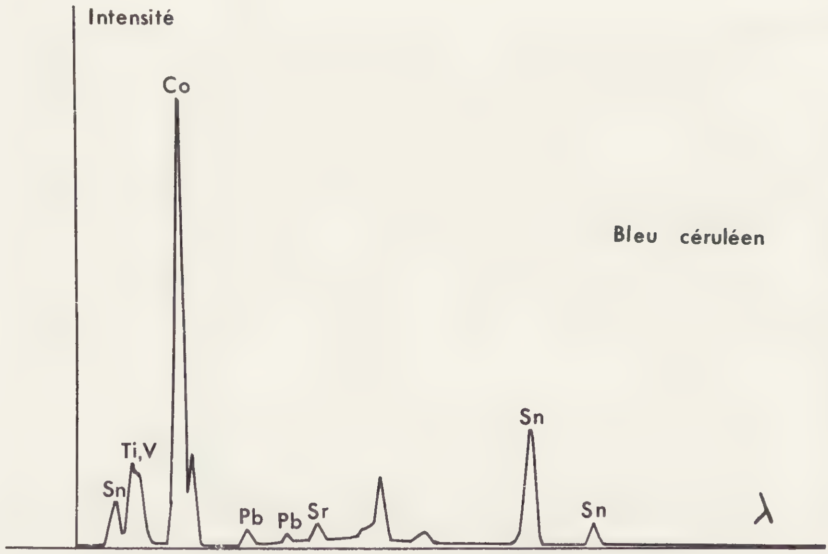
Pour l'analyse des pigments, une technique complètement non destructive, mise au point par Christian Lahanier, responsable du service de physique au L.R.M.F., a été employée. Il s'agit de l'analyse par microfluorescence X qui fournit une identification directe des pigments minéraux présents à la surface de la peinture.

Dans l'appareil qui est utilisé au Laboratoire, l'excitation de la plage à analyser est produite par un tube à rayons X qui provoque l'émission d'un spectre de rayons X caractéristique de la composition des pigments. La détection et l'analyse de ce rayonnement de fluorescence s'opère au moyen d'un système dispersif en énergie composé d'une diode au silicium couplée à un analyseur multicanal. Le spectre panoramique des éléments présents apparaît instantanément sur l'oscilloscope et peut être reproduit sur papier au moyen d'une table traçante couplée à un calculateur.

Les spectres panoramiques obtenus, constitués de pics caractéristiques des éléments composant la matière picturale analysée, sont représentatifs des couleurs minérales



Spectrogramme de microfluorescence X, d'après la "Grande nature morte au guéridon". Couleur orange : jaune de cadmium (CdS) et vermillon (HgS)



Spectrogramme de microfluorescence X, d'après la "Femme à la montre". Couleur bleu pâle : bleu céruléen CoO, $nSnO_2$ et blanc de plomb

utilisées par Picasso pendant plus de 65 années de son oeuvre, de 1895 à 1961.

L'analyse par microfluorescence X a été particulièrement bien adaptée à cette étude, car les couleurs de Picasso sont précisément dans la plupart des cas obtenues par l'emploi de pigments minéraux, de composition chimique bien définie, employés purs, et donc aisés à mettre en évidence par cette technique.

Nous indiquons ci-dessous les pigments ainsi identifiés qui constituent la majorité de ceux dont Picasso s'est servi. Il est bien évident que nombre d'autres couleurs, en particulier les couleurs organiques, n'ont pu être identifiées avec cette certitude.

Les blancs

La majorité des blancs décelés sont composés de blanc de plomb -avant 1925 et après 1937- et de blanc de zinc -entre 1925 et 1937-. Ces deux blancs sont parfois mélangés entre eux ou avec des blancs de titane.

La comparaison des proportions des éléments présents à l'état de majeurs ou de traces devrait permettre de classer chronologiquement les différents blancs.

Les rouges et les jaunes

Picasso a utilisé essentiellement pour les couleurs rouges des vermillons (HgS) que l'on retrouve tout au long de son oeuvre. Quelques ocres sont également rencontrées.

Les rouges et les jaunes de cadmium (CdS(Se) et CdS) ont été employés à partir de 1924.

On rencontre aussi quelques jaunes de strontium ($SrCrO_4$) et jaunes de chrome ($PbCrO_4$).

Les verts

Les verts les plus fréquemment présents sont :

- des verts de chrome, opaques (Cr_2O_3) ou transparents (Cr_2O_3, $2H_2O$),
- des verts émeraude (acéto arséniate de cuivre) utilisés après 1917,
- des mélanges de jaune de cadmium (CdS, avec ou sans $BaSO_4$) et de bleu de Prusse,
- dans un cas (1938) un mélange de jaune de strontium ($SrCrO_4$) et de bleu.

Les bleus et les violets

Les bleus de cobalt (CoO, Al_2O_3) sont utilisés jusqu'en 1939, de même que les violets de cobalt, le cobalt étant dans ce cas associé ou non à l'arsenic ($Co_3(PO_4)_2$ ou $Co_3(AsO_4)_2$).

Les bleus de Prusse (présence de Fe) sont également fréquents.

Le bleu céruléen (CoO, $nSnO_2$) est quelquefois rencontré.

Les bleus d'outremer et les bleus organiques ne peuvent être distingués par l'analyse par microfluorescence X. Un

grand nombre de couleurs bleues n'a pu de la sorte être identifié.

Les bruns

Ces couleurs sont toutes à base de fer et peuvent être des terres naturelles ou des ocres artificielles (couleurs de Mars).

Les traits bruns épais qui cernent certaines des grandes figures sont constitués, soit de ces mêmes pigments dilués dans le liant comme dans "La flûte de Pan" (1923) et les "Figures au bord de la mer" (1931), soit de noir animal comme dans "La nageuse" (1929).

Les noirs

De même, les noirs sont composés de noirs d'os (dont témoigne la forte présence de Ca), de noirs de fer (forte présence de Fe) et de noirs de carbone (que la microfluorescence X ne peut détecter mais qui ont été déduits par élimination). Ces différents noirs se retrouvent simultanément utilisés tout au long de l'oeuvre de Picasso.

LES LIANTS

L'analyse des liants a été effectuée sur de minuscules prélèvements de matière picturale, et elle a été réalisée par Jean-Paul Rioux, responsable du service de chimie au L.R.M.F.

Les méthodes utilisées ont été multiples. D'une part les tests et colorations spécifiques sur coupes minces ont permis de mettre en évidence la présence d'acides gras, de protéines ou de résines au sein de ces coupes. D'autre part la chromatographie en phase gazeuse a pu caractériser avec précision l'origine de l'huile.

Les résultats rapportés ici ne concernent qu'une première série de tableaux (repérés par une croix sur la liste donnée en annexe), l'étude des liants pour l'ensemble des oeuvres étant actuellement en cours.

Il apparaît que les couleurs, dans tous les cas examinés, sont étendues avec un liant contenant de l'huile. Celle-ci est parfois de l'huile de lin pure, mais le plus souvent de l'huile d'oeillette, employée pure ou mêlée d'huile de lin.

Plusieurs types de matière picturale peuvent être distingués, les différents aspects observés correspondant à des compositions spécifiques du liant.

1- une peinture à l'huile sans particularité notable observée à toutes les époques.
2- une peinture à l'huile très brillante, d'aspect fluide, présentant des empâtements arrondis. Il s'agit d'une matière très riche en huile.
3- dans certains cas, des résines naturelles ont été ajoutées à certaines couleurs de façon à accentuer leur brillant, comme par exemple dans le noir de la "Tête d'homme barbu" (1938) ou le jaune vif de "La Crucifixion" (1930).

L'addition de matières résineuses est également probable dans certains blancs pauvres en huile et ayant peu jauni avec le vieillissement. On observe ce cas dans "La femme assise" (1920), "La lecture de la lettre" (1921), "La suppliante" (1937), (ce dernier tableau ne peut donc être considéré comme une gouache comme on a pu le supposer).

4- une peinture très mate, d'aspect pâteux. Le liant est alors une émulsion très dispersée de colle protéinique dans l'huile.

Peinture brillante et peinture mate juxtaposées sur un même tableau sont souvent observées entre 1936 et 1939. Citons la "Femme au buffet" (1936), la "Femme à la montre" (1936), la "Grande baigneuse au livre" (1937), la "Tête d'homme barbu" (1938), le "Chat saisissant un oiseau" (1939).

Signalons enfin que sur aucune des peintures étudiées il n'a été décelé l'emploi de résines synthétiques, de peintures cellulosiques ou glycérophtaliques.

CONCLUSION

Les résultats obtenus par cette étude ne sont encore que partiels.

Lorsqu'ils seront complets, ils devraient éclairer largement plusieurs aspects de la création artistique de Picasso, ceux qui concernent la conception formelle et matérielle de son oeuvre peint, tant sur le plan de ses recherches plastiques que sur celui de l'utilisation rationnelle des matériaux de son temps.

Picasso, contre toute attente, brisant l'hypothèse facile à exprimer que dans la touche fougueuse, libérée de l'artiste ne devrait se trouver que les stigmates de cette indépendance, au contraire dans la structure profonde de la matière, dans le choix des couleurs qu'il veut pour la plupart minérales, il reprend l'enseignement des classiques et nous démontre son attachement aux préceptes du passé. Etonnante leçon que nous donne ce peintre, d'autre part tellement novateur par ses modes d'expression et sa démarche analytique, lorsqu'à l'égal des peintres anciens, il prépare avec soin ses supports par une ou deux couches d'enduit blanc ou teinté, il choisit des pigments et des liants d'excellente qualité, lorsqu'enfin il réalise de multiples esquisses préparatoires, même si à la différence des maîtres classiques, il attribue une part prépondérante à la génèse picturale, donnant autant d'attention à toutes les étapes successives de la création de l'oeuvre.

De plus, et ce n'est pas le moindre intérêt de cette étude, il pourra s'établir une liaison entre la chronologie des tableaux et l'usage des différentes couleurs systématiquement identifiées, créant une banque de références analytiques, de données objectives, qui ajoutera autant de critères supplémentaires d'authentification aux critères habituels d'ordre stylistique ou historique.

81/6/2-8

Liste chronologique des tableaux étudiés

	L'homme à la casquette - 1895 n° cat. (§)	1
	La fillette aux pieds nus - 1895	2
	La mort de Casagemas - 1901	3
(+)	Autoportrait - 1901	4
	Les deux frères - 1906	8
	Jeune garçon nu - 1906 ?	9
(+)	Autoportrait - 1906	10
(+)	Buste d'homme - 1907	20
	Buste de marin - 1907	21
	Buste de femme aux mains jointes - 1907	22
	Mère et enfant - 1907	25
(+)	Paysage aux deux figures - 1908	40
(+)	Homme à la mandoline - 1911	49
(+)	Nature morte à la chaise cannée - 1912	50
(+)	Guitare "J'aime Eva" - 1912	51
(+)	Homme à la cheminée - 1915	94
(+)	Le repas des paysans, d'après Le Nain - 1917	96
	Les amoureux - 1919	103
(+)	Nature morte à la commode - 1919	108
	Nature morte au pichet et aux pommes - 1919	109
	Tête de femme - 1920	111
(+)	Femme assise - 1920	112
(+)	La lecture de la lettre - 1921	117
(+)	La flûte de Pan - 1923	125
	Paul dessinant - 1923	127
(+)	Paul en arlequin - 1924	130
	Paul en pierrot - 1925	131
(+)	Le baiser	132
	Le peintre et son modèle - 1926	143
(+)	Baigneuses sur la plage - 1928	158
(+)	Grand nu au fauteuil rouge - 1929	166

(§) Catalogue de l'exposition "Picasso, oeuvres reçues en paiement des droits de succession", Paris, Grand-Palais 11 octobre 1979 - 7 janvier 1980

(+) Tableaux ayant fait l'objet d'une étude de liants

WATERLOGGED WOOD

Coordinator: C. Pearson (Australia)

Members : L. Barkman (Sweden)
A. Daldorff (Norway)
N. Gerassimova (USSR)
G. Grosso (USA)
B. Hafors (Sweden)
J. de Jong (Netherlands)
K. Jespersen (Denmark)
C. McCawley (Canada)
E.G. Mavroyannakis (Greece)
A. Mihailov (Bulgaria)
J. Pang (Australia)
C. de Tassigny (France)
N. Yachvili (USSR)

Programme 1978-1981

1. Use of detergents in the conservation of waterlogged wood (Jespersen).
2. Use of tetraethyl ortho silicate (Jespersen, Pearson, Pang).
3. Problems connected with the salvage of non-conserved waterlogged wood (Jespersen, Pearson).
4. Freeze-drying of waterlogged wood (McCawley, Daldorff, Pang).
5. Methods of analysis of PEG in waterlogged wood (Pang).
6. Use of sucrose in the treatment of waterlogged wood (Hafors, McCawley, Grosso, Barkman).
7. Use of organic polymers in the treatment of waterlogged wood (Gerassimova, Yachvili, Mavroyannakis).
8. Irradiation techniques for the treatment of waterlogged wood (de Tassigny).

81/7/1

RECENT ADVANCES IN THE CONSERVATION OF WATERLOGGED WOOD

Colin Pearson

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Waterlogged Wood

RECENT ADVANCES IN THE CONSERVATION OF WATERLOGGED WOOD

Colin Pearson

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Abstract

The progress of the Working Group on Waterlogged Wood during the period 1978-80 is described. The main progress has been in the bulk freeze drying of waterlogged wood using the permafrost of the Canadian winters. In addition, details of two international meetings on the conservation of waterlogged wood are given. An important contribution to communication between workers in this field has been the introduction of a Newsletter, produced twice a year.

General

The Working Group on Waterlogged Wood has been very active during the past three years. In addition to slow but sure progress in conservation treatments, by the time of this Congress, two international conferences on the conservation of waterlogged wood will have been held, also, a regular Newsletter is now being published.

Conferences

1. International Symposium on the Conservation of Large Waterlogged Objects, Amsterdam, September 1979

An international symposium was held at the National Maritime Museum in Amsterdam under the auspices of the Netherlands National Commission for Unesco and the "Save the *Amsterdam*"

Foundation with additional sponsorship from Unesco. The aim of the Symposium, which was attended by 37 experts from 12 countries, was to discuss the problems of the conservation of large objects of waterlogged wood with particular reference to the wreck of the *Amsterdam* (1749).

Delegates presented papers on various conservation treatments currently being used including polyethylene glycol/tertiary butanol and polyethylene glycol/water impregnation, freeze drying, gamma radiation polymerisation, resin impregnation and controlled air drying. These processes were discussed in relation to their application to the treatment of large composite waterlogged wooden objects such as ships hulls.

During the Symposium a visit was made to the Conservation Laboratory and Museum for Maritime Archaeology at Ketelhaven, also the Research Laboratories, IJsselmeerpolders Development Authority, Lelystad.

Recommendations:

The International Symposium organized by the Netherlands National Commission for Unesco and the "Save the *Amsterdam*" Foundation with additional sponsorship from Unesco,

attended by researchers from 13 countries, having regard to the current state of international research on the conservation of waterlogged wood and in particular of large wooden structures,
considering that when such conservation concerns old wooden vessels, the safeguard must necessarily involve:

- evaluation of the national or international relevance of the vessel and its contents
- complex engineering operation of salvage and transport
- archaeological excavation at an underwater or wet site
- conservation of the vessel and its contents
- restoration of the vessel and its contents
- future care and public display of the vessel and its contents,

deeming it important that more emphasis be given to the conservation of large waterlogged wooden objects, and that therefore more resources be allocated for this purpose, made the following recommendations:

a. In view of evaluating existing conservation methods the Symposium concluded that controlled drying with possible surface treatment with PEG (4000) is an acceptable solution for large waterlogged objects such as the "*Amsterdam*" and the "*Mary Rose*". This conclusion is based on both the current insoluble technical problems and financial consequences of extending the scale of other methods. It is also based on the fact that the

wood of both the "*Amsterdam*" and the "*Mary Rose*" is in a very good condition. However, results from controlled drying techniques are not sufficiently available and it is recommended that further research into controlled drying be initiated in the Netherlands.

b. Although some existing methods are not currently feasible for treating large composite objects such as ship-hulls, it is recommended that further development of these methods and the research for new methods be stimulated. Methods to conserve sites in situ should also be developed. Furthermore it is suggested that existing methods be tested in one laboratory. The representative of "Le Centre d'etudes nucleaires de Grenoble", France, expressed his willingness to carry out such research. Unesco will be asked to take into consideration financial support for such research programmes.

c. It is desirable that there should be another meeting as a Follow-up to the present symposium in two or three years time. This and subsequent meetings as part of a continuing programme could be organized by Unesco and the Working Group on Waterlogged Wood of the ICOM Committee for Conservation. It is also recommended that Unesco be invited to include the subject of wet-site or underwater archaeology in its Regular Programme.

d. It was clear from the papers presented to the Symposium and subsequent discussion that the criteria applied to the examination of wood samples, and the methods, varied considerably as did the results. It was therefore agreed to have a number of identical wood samples analysed in different laboratories with respect to water-content, ash, cellulose, hemicellulose, lignin, iron and chlorides. A sub-committee will establish methods of analysis according to the international standards. Only in this way can results be compared. Dr P. Hoffmann, Stiftung Deutsches Schiffahrtsmuseum, Bremerhaven will provide a set of standard analyses for the characterisation of waterlogged wood. Samples will be sent out accompanied with as many particulars as possible on dating, kind of wood, environment, etc. The samples will come from Denmark (Mrs K. Jespersen, Nationalmuseet, København), the Netherlands (Dr J. de Jong, Rijksdienst voor de IJsselmeerpolders, Lelystad) and of the "*Mary Rose*" from Britain (Mr R.F. Harrison, Mary Rose Trust, Portsmouth). Mr G.D. van der Heide will collect the results and distribute them to each of the participating laboratories. After analysis the samples will be conserved by each laboratory.

e. The results of all research should be published in the Newsletter of the ICOM Committee for Conservation Working Group on Waterlogged Wood, and if possible, in relevant Unesco publications.

f. Criteria regarding the decision whether to conserve or not to conserve large objects of waterlogged wood are to be prepared. A draft shall be submitted by Mr G.D. van der Heide and Mr J. Lodewijks and sent to the participants and other interested specialists for their comments.

It is hoped that the papers presented to the Symposium will shortly be published.

2. International Conference on the Conservation of Waterlogged Wood
Ottawa, September 1981

The Canadian Conservation Institute is organising a four day Conference in Ottawa prior to the ICOM Committee for Conservation Meeting. The Conference will be divided into four sessions:

(a) The Treatment of Shipwrecks

(b) The Treatment of Land Sites

(c) The Analysis and Classification of Waterlogged Wood

(d) Progress in the Treatment of Waterlogged Wood.

Selected speakers will be invited to present papers, in addition there will be a general call for papers. There will also be a poster display to review projects or processes under way, and a visit to the laboratories of CCI and the Historic Sites Division of Parks, Canada, to view waterlogged wood undergoing treatment. It is anticipated that there will be in excess of 100 delegates attending the Conference. A report of the Conference will be presented to the Meeting of the Working Group on Waterlogged Wood at the ICOM Committee for Conservation 6th Triennial Meeting.

Newsletter

Following a resolution passed at the ICOM Committee for Conservation Meeting in Zagreb, December 1978, a Newsletter has been produced by the Working Group Coordinator. The aim of the Newsletter is to further communication and exchange of ideas and information between those interested and/or involved with the conservation of waterlogged wood. Initially, the Newsletter was circulated to the 14 members of the Working Group. This has now widened and there are approximately 100 interested or actively involved members on the mailing list covering 22 countries. Further Newsletters have been published, one in 1979 and two in 1980. It is hoped to produce two editions each year, however, this will depend on contributions from members - the reason for the Newsletter.

The financial burden of printing and mailing the Newsletter has been alleviated by a grant, in 1980, from the Unesco Division of Cultural Heritage. In addition, the distribution list has been increased to 400 to cover National Antiquities Organisations and Museums that have interest in this field.

Conservation of Waterlogged Wood

There has been steady progress in the conservation treatments used for waterlogged wood. The attached Bibliography indicates the papers published since 1978. There do not appear to be any major developments, however, one interesting project is the use of the permafrost for freeze drying waterlogged wood. This is being studied by the Canadian Conservation Institute (see Bibliography) and appears to be a relatively cheap method of treating large quantities of timber.

Another area of concern, more than progress, is the problem of describing the condition of waterlogged wood. This was raised at the Amsterdam Symposium (see section d. of the recommendations listed earlier) and has been discussed by various contributors to the Newsletter. It will also be an item for discussion at the Ottawa Waterlogged Wood Conference. Hopefully, all conservators will be able to agree on standard techniques for analysing and describing the condition and properties of waterlogged wood. This should then make more valid the comparison of the many and varied treatments used for waterlogged wood, which hopefully will help to explain why some treatments work on some woods and not on others, and why some conservators have problems treating waterlogged wood whereas others claim 100% success.

As regards this last point - an appeal for conservators to report on their failures which are as important as their successes, particularly if the reasons for the failures are known. Many fields of conservation have available tried and established techniques that can be applied with confidence to a work of art or artifact with a more or less guarantee of success. This does not apply in the conservation of waterlogged wood. Hopefully, we are now moving in this direction.

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81/7/2

CONTROLLED DRYING AS AN APPROACH TO THE CONSERVATION OF SHIPWRECKS

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ICOM Committee for Conservation
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Working Group: Waterlogged Wood

CONTROLLED DRYING AS AN APPROACH TO THE CONSERVATION OF SHIPWRECKS

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Summary

In moist or wet conditions wood degrades under the influence of both microbiological and physico-chemical decaying processes. The extent of decay is reflected in the water content of European oak in waterlogged condition, as well as in the chemical composition of the wood. It was found that the shrinkages after drying are also directly related to the degree of degradation. The more degraded the wood the higher the shrinkages are.
In a number of cases shipwrecks or parts of wrecks have been excavated consisting entirely of hardly degraded wood. In such cases controlled drying may be an approach to the conservation and results of this way of conserving large objects are described in this paper.

Introduction

During the reclamation and the development of the new polders in the central part of the Netherlands, the former Zuiderzee, many finds of archeological and historical value have been discovered. The finds may vary from remains of Neolithic settlements, remains of medieval habitation, through shipwrecks to crashed aeroplanes dating from World War II.
The Zuiderzeeproject comprises the construction of a 32 kilometer long barrier dam separating the former Zuiderzee from the North Sea and the construction of five polders in the resulting fresh water lake, Lake IJssel (Fig. 1). The primary aims of the projects being: an increase of safety, an increase of the area of arable land and an improvement of water management of the surroundings of the Zuiderzee. Many of the finds are completely covered with clay and are only found when works are done in the subsoil e.g. for agricultural development, afforestation or urban development. The shipwrecks found in these polders date from the Middle Ages to recent times. The number of wrecks found so far is approximately 370 and still more wrecks will be found. The IJsselmeerpolders Development Authority is in charge of the research of the wrecks. The work is carried out bij the Scientific Department of this Authority. The Museum of Maritime Archeology at Ketelhaven is a

subdivision of the Scientific Department.

A number of the shipwrecks found in the Lake IJssel polders, but also wrecks found at other sites (e.g. Zwammerdam, Utrecht), were considered to be of such interest and value that it was decided to add them to the collection of the Museum of Maritime Archeology at Ketelhaven; so the wrecks and many other wooden items had to be conserved.
About the development of conservation methods suited for the treatment of large quantities of waterlogged wood has been reported (1, 2, 3, 4). On the other hand the rate of discovery of wrecks exceeds the excavation, research and conservation capacity. Valuable objects are to be protected in situ (4, 5), or to be excavated and conserved.

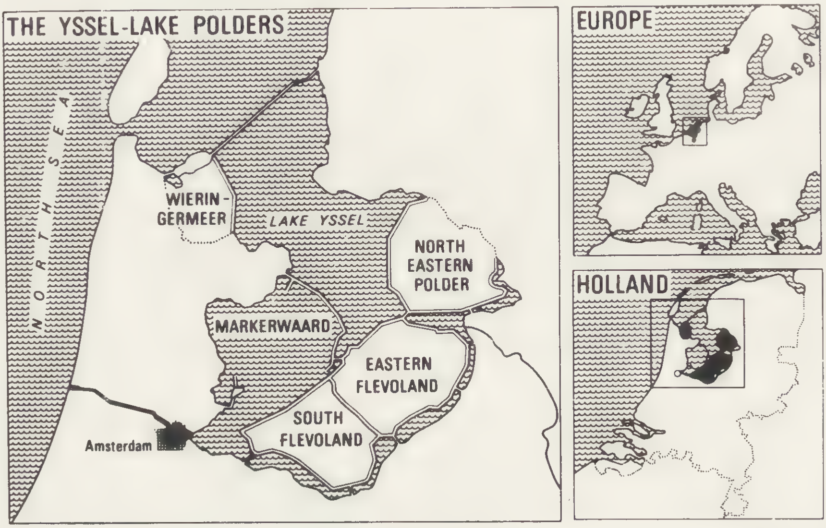


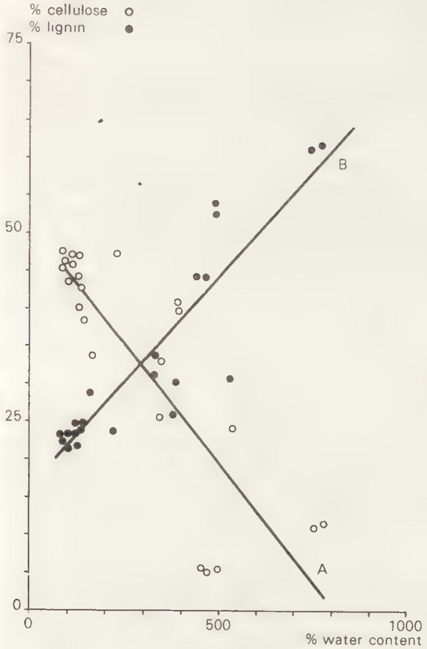
Fig. 1. The Zuiderzee Land reclamation and development project

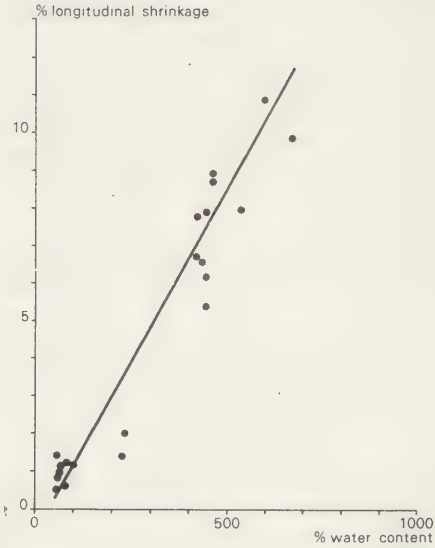
With respect to the conservation of shipwrecks or large parts of a ship's construction, it was found that controlled drying might be a possibility for their conservation.

Controlled drying

During the investigations into methods for the conservation of waterlogged wood from shipwrecks it was observed that in some cases the wood was in a very good condition. From a chemical point of view it was almost identical to new wood. Another very important observation was that the shrinkage behaviour of the wood too was comparable to the shrinkage that occurs in new wood, if dried under the same conditions.

The amount of shrinkage occurring in old waterlogged wood after drying appears for european oak to be correlated with the amount of degradation of the wood as reflected in its chemical compositions, as can be seen from table 1.





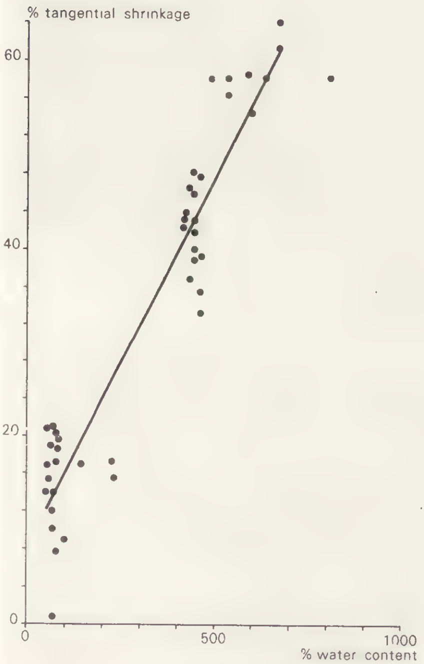


Fig. 2

The linear regression between cellulose content, lignin content longitudinal shrinkage and tangential shrinkage with the water content of old waterlogged european oak heartwood (cellulose and lignin content as % of the dry wood materials, shrinkages expressed as % of the waterlogged dimensions).

Table 1. The chemical composition of old waterlogged European oak heartwood and its shrinkage behaviour at various stages of degradation.

Origin of the wood	Content in % of the oven-dry wood			Shrinkage upon drying from waterlogged to oven-dry (105^{o}C, 24 h) in % of the wet dimensions		
	water	cellu-lose	lignin	longitu-dinal	radial	tangen-tial
New	100-120	50-65	25-32	0.4	5	11
Utrecht ships	130	45	25	1	8	19
Zwammerdam ships	100-120	47	23	0.5	13	21
Bremer Kog	120-145	-	-	-	10	20
Bremer Kog	-	46	36	-	-	-
Wasa	$\pm$ 150	67	29	-	-	-
Utrecht ships	375-415	5.5	51	10	10	33
Zwammerdam ships	375-400	5.5	51	13	11	47

From this table it is obvious that correlations between water and cellulose or lignin content are present, but also between water content and shrinkage behaviour. In order to analyse this in more detail for the individual measurements on wood samples from wrecks found in the IJssel lake polders, the Zwammerdam ships and the Utrecht ships the coëfficiënts of correlation for linear regressions are given in table 2.

As can be seen from table 2 and Figure 2 all correlations are significant with an exception for the radial shrinkage. However, it is often difficult to measure this radial shrinkage sufficiently accurate due to limited sample sizes and crack formation.

From these results it is clear that the less degraded the wood is, the lower its water content in waterlogged condition will be and the smaller the shrinkages after drying.
In the cases when the wood is only slightly degraded, controlled drying offers the opportunity for a rather inexpensive method for the conservation, provided that either a certain degree of surface damage is accepted or one has to remove the thin damaged surface layer before exposition.

It was found that in some cases the wood of wrecks was of such a good quality that the wreck could be dried at the excavation site without any precaution (Figure 3).

Table 2.

The coëfficiënts for correlation for a linear regression of the water content in old waterlogged European oak heartwood with cellulose content, lignin content and the shrinkages occurring upon drying.

Correlation of water content with	coëfficiënt of correlation
cellulose content	0.84
lignin content	0.91
longitudinal shrinkage	0.94
tangential shrinkage	0.95
radial shrinkage	0.53

Fig. 3. The wreck of a 19th century ship, dried at the excavation site, without any precaution

To investigate the possibilities of drying in more detail, samples have been taken of the timber of various wrecks. They come from a 17th century wreck which was kept under a shower installation at Ketelhaven (sample sizes approx. 200 x 10 x 25 cm and 200 x 4 x 20 cm) and consist of both oak and pine. The samples were dried under laboratory conditions (approx. 20°C, 70 40-60% r.h.) and smaller samples were oven dried (105°C, 70 hours). It was found that the shrinkages were comparable to those occurring in new wood. During the drying only a very slight surface cracking developed.
In 1978 also samples could be taken from the 18th century wreck of the VOC-ship "Amsterdam" (a ship of the Dutch East Indian Trade Company) which lies near Hastings in England. These samples

were also only slightly degraded. Some samples were dried too. The recorded data are listed in table 3.

Table 3.
The shrinkage data measured for new and slightly degraded old waterlogged wood.

Wood (origin/ species)	% shrinkage based on wet dimensions of the wood					
	Air dry			Oven dry (105 °C, 70 h)		
	l	r	t	l	r	t
New European oak heartwood	-	-	-	0.4	4.8	10.6
new pine	-	-	-	-	3.9	7.7
VOC-ship Amsterdam; oak	0.4*	3.9*	8.0*	1.1	4.2	5.8
Ship E-81 (Ketelhaven						
oak heartwood	0.3	-	9.2	0.4	-	12.1
pine	0.2	-	4.2	0.4	-	6.3

* after 87 weeks of drying

In view of these results, a 12m long wreck and a piece of a carvel build ship was dried as an experiment.

Methods and results

Before starting the drying of the wreck a number of provisions are made. Around the wreck, which was originally placed under a shower installation in the museum, a tent of vapour-tight transparant plastic sheeting was constructed. This was done in order to prevent the wreck from drying too fast, and to make it possible to control relative humidity near the wreck independantly from the other parts of the museum.
The wreck itself was provided with additional temporary supports to minimize the risks of deformation during the drying process. By means of natural ventilation through openings of approx. 0.5m^2 at the bottom and the top of the tent the relative humidity was gradually decreased from almost 100 % to the normal condition in the museum. Relative humidity in the tent has been continually measured.
The occurring shrinkages have been measured at 12 sites in the wreck. The measurements were confined to the recording of tangential shrinkages on plankings, except for one site where the longitudinal shrinkage was measured for a period of 28 months.

In this period the longitudinal shrinkage was 0.2 %. The tangential shrinkages were found to vary from one measuring site to the other as is to be expected for an inhomogeneous material as wood. The lowest value after 28 months was 4.1 %, the highest 12.6 %, the average value of twelve sites 7.7 %. At that time the wood was stabilized at prevailing museum conditions, as can be seen from Figure 4. On the surface of the wood a thin layer of more degraded wood is present, resulting in the well known formation of a craquelé surface, which easily can be removed. The overall result, however, is good (Figure 5).

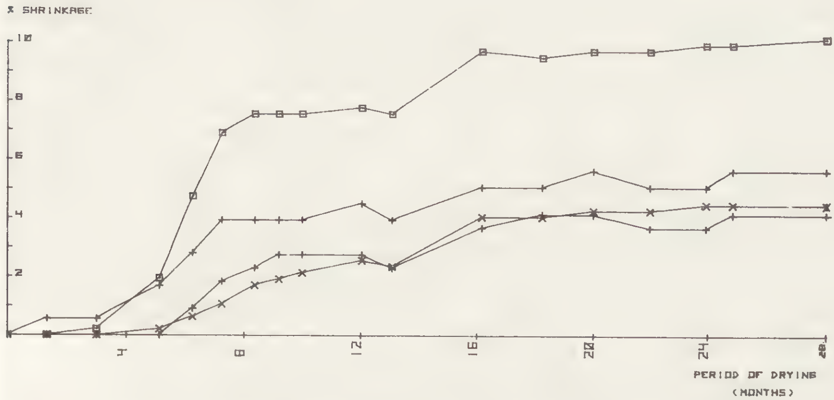


Fig. 4. The tangential shrinkage of 4 sampling sites in the 12m wreck during controlled drying

Fig. 5. Part of the 12m wreck after controlled drying (sternpost side)

Also for the section of a ship's hull the results can be shown. Figure 6 gives an impression of the wooden structure while waterlogged. The hull section was then dried and restored. Figure 7 shows the innerside of the object after drying.
The restoration was done by removing the individual pieces of timber one by one and brushing the thin craquelé surface layer away after which the timbers were put back into their positions using new wooden pins, after which by means of a brush a wood preserving agent is applied. The final result is shown in Figure 8, where the object is ready for exposition.
These observations, combined with the collected evidence on the the possibilities of succesfull drying of large segments of shipwrecks and preparing them for exposition, encouraged the start for controlled drying of two more wrecks. The drying of one wreck (27m long, 17th century) has been started and the drying of the second one (18m ong, 16th century) will start in spring 1981.

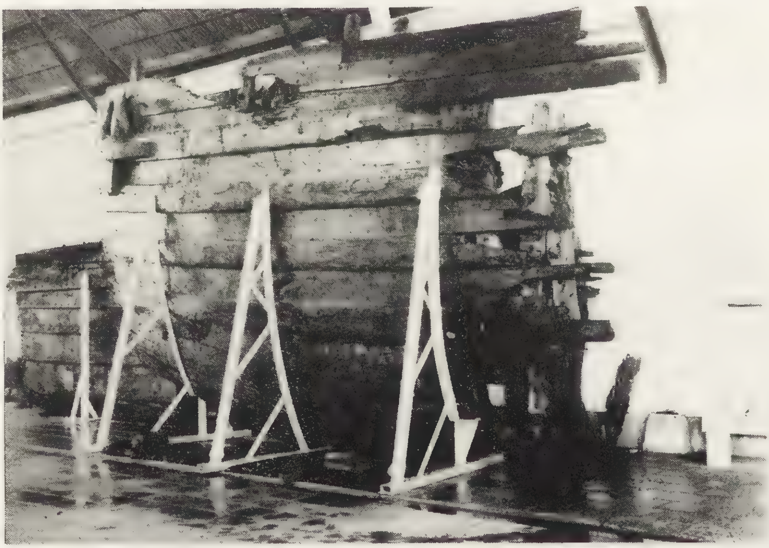


Fig. 6. Section of a ship hull, carvel build, in waterlogged condition

Fig. 7. Section of a ship hull after drying

Fig. 8. Section of a ship hull after the restoration, ready for exposition

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THE CONSERVATION OF A WATERLOGGED DUG-OUT CANOE USING NATURAL FREEZE-DRYING

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6th Triennial Meeting
Ottawa 1981

Working Group: Waterlogged Wood

THE CONSERVATION OF A WATERLOGGED DUG-OUT CANOE USING NATURAL FREEZE-DRYING

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Abstract - Freeze-drying can be accomplished without the use of expensive equipment.

The conditions necessary to achieve this are found in the winter climate of many parts of Canada; temperatures that stay below zero for several months keep the wood frozen; many hours of bright sunshine per day warms the wood; a low humidity allows an efficient drying atmosphere for the wood; and finally, wind helps remove water vapour from around the wood.

It has been shown that, despite certain limitations, it can be a successful method for dealing with many types of waterlogged wood, but less so if the wood is badly degraded. It was also shown that pre-impregnation with 15% v/v solutions of polyethylene glycol 400 before drying improved the results considerably, and an average of 76% anti-shrink efficiency was obtained for all of the pieces treated. In the two to three-month period of winter in which suitable conditions prevail, about 50% of the water was removed on average from the test pieces under study (depending on size, shape, etc.); however, this drawback is not as serious as might be anticipated. The method could be useful for much archaeological material.

The treatment was successfully carried out with a waterlogged log canoe of white pine (*Pinus strobus*).

1. INTRODUCTION

The problems posed in the stabilization of degraded, waterlogged wood have been often and well documented and need only briefly be mentioned. Air-drying, without pre-treatment of the wood, generally results in severe irreversible shrinkage, surface checking and other deformation.

These effects are normally attributed to the movement of water through the wood; the force associated with a water meniscus (i.e. surface tension) can cause the irreversible collapse of damaged wood cells. If the meniscus is moving, as will take place during drying when water migrates to the surface of the object, the damage may be widespread and severe. There may be other effects, such as the loss of bound water, which will also cause dimensional change. Conservation treatments attempt to remove the water without leaving the wood in an irreversibly damaged condition. Freeze-drying has been one of the techniques used with some success.

It has been demonstrated that it is not necessary to use vacuum chambers for freeze-drying of waterlogged wood and it occurred to the authors that the winter climate of much of Canada has conditions ideal for freeze-drying. In Ottawa, for example, the temperature stays well below zero for three to four months, averaging -10°C from January to March. There are approximately 5 hours of sunshine per day to offset the latent heat of sublimation. The windy conditions, averaging 12 km/h over the winter months, help remove the water-saturated air from around the object. Recognizing that suitable conditions occur in Ottawa, the aim was to test the practicality of external freeze-drying of waterlogged wood.

The method of freeze-drying is as follows:
Prior to drying, much of the wood was impregnated for four months in cold, stirred tanks of 10 and 15% aqueous solutions of polyethylene glycol (PEG) 400. The wood, which had been previously frozen in a deep-freeze at -25°C, was placed outside in a suitable shelter at the beginning of January when there was little risk of temperatures in excess of 0°C occurring. Drying was continued for two and a half months, and then the wood was brought into the laboratory where the final drying took place. When the wood had adjusted itself to the climate within the building (20°C, 38% RH in winter; 20°C, 55% RH in summer), final shrinkage measurements were taken. (This condition of equilibrium was established by following the weight changes in the wood.) The final examination of the wood was made in the following August when all of the wood had completely equilibrated and all weight losses had ceased.

To house the wood for the experiment, a tent with transparent polyethylene walls was built. It was constructed strongly to withstand high winds and severe winter weather. The objective was to keep the wood used in the experiment free from precipitation but to expose it to the exterior temperature, wind, humidity and sunlight as much as possible. In addition, the tent housed instruments for the measurement of the temperature, the RH and the weight of the wood. The tent was triangular in cross-section with 1·22m sides and a length of 3·67m. The steeply pitched roof prevented snow build-up, thus ensuring that the wood would be exposed to the radiation from the sun. The frame was made from standard 5 x 10 cm construction grade spruce, held together with white woodworking glue and 9 cm galvanized nails. The floor was of 1·6 cm plywood, and the walls of the tents were constructed of hinged, transparent louvres to increase lateral air circulation in the models used in the second winter of experimentation. It proved to be a slightly more successful approach.

RESULTS

The Effect of the Climatic Conditions on Drying Rate

Experiments were carried out in 5 locations across Canada. In each, three pieces of wood were used: Number 44 *Pinus strobus* (30 x 14 x 3 cm) with a water content of 282% from a marine shipwreck of 1866; Number 41 *Quercus alba* (20 x 15 x 10 cm) of water content 140% known to have been submerged in shallow fresh water for approximately 100 years; Number 54 (6 x 9 x 9 cm) *Acer* (*saccharinum*?) of 290% water content, from the same source as 41. In each location, the experiment was begun early on the afternoon of 2 January 1979, at which time the wood specimens were placed in the driers, and terminated at noon on 9 March. Each apparatus was monitored twice weekly; the procedure consisted of (a) removing any snow from the drier, (b) weighing the wood, (c) noting the weather conditions, (d) reading and re-setting the maximum-minimum thermometer, (e) recording the temperature of the interior of No. 41. At the end of the experiment, the wood was brought into the laboratory and allowed to come to equilibrium with room conditions. In Figure 1 the rate of loss of water for No. 54 in each of the five locations is shown. It is immediately apparent that in the colder locations, such as Yellowknife, water was lost much more slowly. This is shown more clearly in Table 1

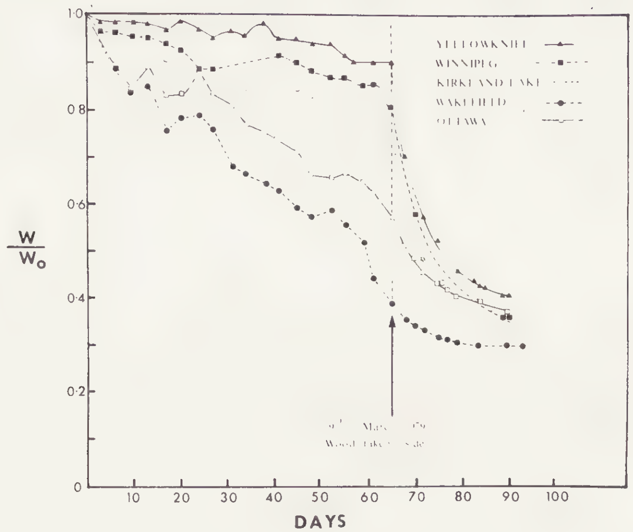

Fig. 1. Loss in weight for No. 54 maple for each location. W/Wo is the weight at time t divided by the weight at zero time.

TABLE 1

Climatological and Weight Loss Data for the Wood Samples Used (CPW 44, 41, 54)

	Ottawa	Wake-field	Kirkland Lake	Winnipeg	Yellow knife
% of removable Water Lost					
No. 44	74	80	20	35	17
No. 41	53	58	25	27	11
No. 54	65	79	27	40	16
Average daily temp.	-11	-14	-16	-22	-30
Average wind velocity	14·8	16	16	15·9	12
Total hours bright sunchine	243	237	220	297	233
Average RH, %	75·5	88	74	80	81

<u>The Effect of Size on the Drying Rate</u>

A study revealed that on average in the winter of 1979 over the three months' drying period that the ice surface receded into the wood about 0·9cm. It was also shown that given a particular set of climatic conditions, reasonably accurate predictions of weight loss could be made if the surface to volume ratio of the wooden object could be determined.

<u>The Effect of Sunlight and of Wind</u>

Surprisingly, it was shown that the presence or absence of sunlight did not greatly accelerate or affect the rate of drying. This was tested in an apparatus containing similarly-sized pieces of three wood samples, with two comparable drying racks, one of which was in darkness and the other exposed to sunlight. A fan directed onto the wood, however, increased substantially the amount of water lost. In this experiment, it was calculated that the ice receded by 2cm below the surface of the wood.

The Effect of PEG on the Drying Rate

Wood impregnated with PEG loses water at a slightly slower rate than non-impregnated waterlogged wood. This can be ascribed to the effect of PEG on the vapour pressure.

The Condition of the Treated Wood and the Shrinkage

Each piece of wood studied was divided into three parts. One part was impregnated with a solution of PEG 400 for five months before exterior freeze-drying, a second was exterior freeze-dried without any impregnation, and a third was simply allowed to air-dry in the laboratory. 10% PEG solution was used for wood of water content above 200%, and 15% for wood below this figure, as suggested by Ambrose (1). Dimensional and weight changes were recorded and comparison photographs taken for all of these pieces.

Several general comments may be made about the results. PEG-treated wood always gave the best result. The cold-impregnation conditions used caused little colour change, such as darkening, to take place. In some species, particularly where iron salts were present, as is typically the case for wood from a marine site, some darkening of the wood took place. The average anti-shrink efficiency (ASE) for exterior freeze-drying of PEG treated and non-treated wood was 76·4 and 19·4 respectively, for tangential shrinkage, and 74·4%and 24·2% respectively for radial shrinkage. Thus pre-impregnation with polyethylene glycol increases the ASE by a factor of three. Check and shake formation are not entirely prevented by the presence of PEG but always reduced in extent. Cross-checking is very effectively dealt with, probably because this problem is caused by excessive longitudinal shrinkage of the degraded outer layer and is thus easily prevented by the PEG. When a thick degraded outer layer is present, as in No. 54, <u>Acer</u> (<u>saccharinum</u>?), the method does not entirely prevent the shrinkage and collapse of the affected area.

Some samples were extremely successfully treated by this method, however, these results raise two main questions which are: is it really necessary to use exterior freeze-drying, and if it is necessary, what is the desirable amount of water which should be removed from the wood?

To investigate this further, a length of No. 54 was taken and divided into 2 cm slices of cross-section 10 cm diameter, weighing about 150 g each. These had been impregnated with a 15% solution of PEG for almost one year. Using a vacuum freeze-drier, they were partially freeze-dried as follows: 54/A, 29% of the water removed, 54/B, 52% of the water removed; 54/D, 81% of the water removed; and 54/C, all of the water removed. 54/C subsequently regained 7% of the original amount of water, by absorption, and 54/A, B, and D did not lose water to complete dryness but maintained 9% of the original amount of water. The average anti-shrink efficiencies (ASE) for four radial and two tangential measurements on each piece were: 54/A 55%, 54/B 74%, 54/C 73%, and 54/D 80%. In other words, partial freeze-drying substantially enhanced the ASE, but complete drying gave the best result. As for check and shake formation, 54/A and 54/D were marginally worse than 54/B and 54/C, but the appearance of the cross-section was little different for each. This piece had a very degraded surface. For 54/D and 54/C, collapse of this degraded zone was almost entirely prevented. For 54/B, the surface had not such a good appearance as 54/D and 54/C because a small amount of collapse had taken place, but 54/A had between four and five times the amount of excessive surface shrinkage compared to 54/B and was by far the worst in appearance. (It was, however, much better than the control sample, which had been air-dried and given no PEG impregnation.)

To conclude, it would appear that for a wood which shrinks little when untreated, i.e. with good structural integrity, simple air-drying with a prior impregnation of PEG 400 is probably sufficient. But where cell collapse takes place on air-drying, which is usually the case for very soft and degraded wood, or where degradation is uneven, it is beneficial to freeze-dry.

The Treatment of a Waterlogged Dug-out Canoe with this Method

A canoe fragment (3 x 0.6 x 0.6 meters) had been discovered in a lake near Ottawa in the summer of 1978. It was decided to treat this with the method of exterior freeze-drying. The case was of *Pinus Strobus* and had an average water content of 140% based on the oven-dry weight of the wood. Prior to treatment, it was allowed to remain in a plywood tank lined with polyethylene

sheet, continuously filtered by means of aquarium filters and a swimming pool pump. The same tank was employed for impregnation in a 15% w/w solution of PEG 400 for three months.

Following the PEG impregnation, the canoe - wrapped in a polyethylene sheet - was removed from the tank and placed in a box lined with "bubble pack". Powdered solid carbon dioxide, at a temperature of -78°C, was then packed around the canoe, which was allowed to freeze overnight. On the following day - December 26, 1978 - it was transported carefully to the roof of the CCI building, where it was to remain throughout the winter.

The canoe was wrapped in a wide mesh net and suspended inside a specially built shelter to protect it from snow and freezing rain. The shelter was 18' (6 metres) long, 4' (1.2 metres) wide at the base, and 6' (2 metres) high. The walls were hinged, transparent, louvred panels, which could be open or shut according to weather conditons.

To monitor the progress of the treatment, accurate weight measurements were frequently taken, something quite difficult to attain in cold weather. Loss of water progressed steadily for 66 days until March 3, 1979, when the daily maximum temperature began to rise above freezing and the relative humidity became very high. The canoe was brought inside on this date, by which time it had lost 34% of its water. These results confirm that complete drying is not always necessary. The removal of the first 30-60% of the water or ice leaves an object in a stable condition. During loss of the remaining water, in the laboratory, the object does not change in appearance or dimensions to any significant degree. It continued its drying at a relative humidity of 55% and temperature of 20°C. The canoe reached an equilibrium with its environment in mid-May 1979, when it weighed 23.7 kg (52.3 lbs.) compared to its initial 54.3 kg (119.7 lbs.) in the wet state.

The finished canoe had a very pleasant light colour and suffered no cracking, checking or shrinkage, whereas if it had been simply allowed to dry-out naturally, it is quite certain that cracks and much unsightly surface checking and shrinkage would have appeared.

This conservation treatment took one third the time of the conventional slow impregnation method, at a fraction of the cost. Since all of the equipment used may be purchased at any lumber or hardware store, and since the PEG 400 impregnant is a cheap and readily available chemical produced in large quantities for the cosmetics industry, this method could be readily and rapidly established at nearly any location in Canada. It could be simply established at any location necessary.

Acknowledgements

We express heartfelt thanks to the many colleagues at CCI who have assisted us, and also to Maurice Mann and Debbie Stewart of the Manitoba Museum of Man and Nature, Donna Midwinter of the Prince of Wales Heritage Centre, Yellowknife and Chuck Pilger of Northern College, Kirkland Lake and Eric Allaby for the recovery of waterlogged wood.

Reference

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A MODIFIED TECHNIQUE FOR TREATMENT OF WATERLOGGED WOOD EMPLOYING THE FREEZE-DRYING METHOD

M. Sawada

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Waterlogged Wood

A MODIFIED TECHNIQUE FOR TREATMENT OF WATERLOGGED WOOD EMPLOYING THE FREEZE-DRYING METHOD

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I. ABSTRACT

Treatment of water-logged wood by freeze-drying has proven to be an effective method of conservation. However, in spite of the growing interest in this technique, a number of problems remain. Shrinkage, cracks, and discoloration often mar the success of the freeze-drying technique.

The author has found that many of the problems associated with freeze-drying can be minimized by : 1) regulating the amount of P.E.G. used in the final impregnation, based on the type and condition of the wood, 2) removing excess P.E.G. prior to freeze-drying, using slightly different techniques to achieve a 'fresh' or 'old' color, 3) using a quick freezing process at the outset of the freeze-drying treatment, and 4) gradually raising the temperature of the vacuum chamber and wooden object in a controlled manner to room temperature.

II. PRETREATMENT

A. General Procedures Presently in Use:

Prior to freeze-drying, the water-logged wood is soaked in successive solutions of ;

1) 40% tert.Butanol in water
2) 60% tert.Butanol in water
3) 80% tert.Butanol in water
4) pure tert.Butanol
5) 20% P.E.G. 4000 in tert. Butanol
6) 40% P.E.G. 4000 in tert. Butanol
7) 60% P.E.G. 4000 in tert. Butanol,

all maintained at about 60°C with a hot water bath. The process normally takes about six months or longer.

B. Recommended Modifications:

Depending on the porosity of the water-logged wood, the percentage of tert. Butanol in the initial bath may be reduced to 10% or 20% for very porous wood, and gardually increased to 40% in an additional step.

The final concentration of P.E.G. 4000 in tert. Butanol should be based on the type and condition of the wood. Generally, if the moisture content of the water-logged wood was below 300% prior to treatment, less than 60% P.E.G. is recommended. Between 300% m.c. and 500% m.c. for hardwoods, or 800% m.c. for softwoods, 60% P.E.G. is suggested. Above 800% m.c., concentrations of P.E.G. higher than 60% should be used. The relationship of moisture content to cellulose

Sample	Moisture content		Cellulose	
	Needle-leaved	Broad-leaved	Needle-leaved	Broad-leaved
A	857	1140	14.2	2.9
B	824	809	17.1	6.6
C	438	744	22.8	11.6

(%)

Table 1. The relationship of moisture content to cellulose content

content is also important in deciding on a final concentration of P.E.G. (see Table 1).

C. Rationale for Using Less than 100% P.E.G. Concentration:

Japanese experience indicates a better response by water-logged wood to changes in RH when impregnated with less than 100% P.E.G. as in the case of freeze-dried wood. In particular, the danger from dissolution of P.E.G. in an excessively high relative humidity is greatly reduced. This is because the P.E.G. is well dispersed within the wood in concentrations of about 60% or less, allowing excess moisture to penetrate the wood without dissolving out the P.E.G.

III. COLOR

After completion of the pretreatment, excess P.E.G. 4000 is removed by soaking the object in a hot solution of tert. Butanol until all but a thin layer remains on the surface. If a dark or 'old' wood color is desired, this thin excess layer can be driven into the wood with a hot air gun after freeze-drying out. If a light or 'fresh' wood color is preferred, the thin excess layer of P.E.G. should be removed completely by lightly applying a cloth dampened with tert. Butanol before freeze-drying.

IV. FREEZE-DRYING

A. General Procedures Presently in Use:

Two basic steps are involved in the freeze-drying of wood to remove solvent. First, the wood is chilled. This can be done any number of ways such as with dried ice. Second, the wood is then placed in a vacuum chamber at room temperature and the solvent is drawn out by the vacuum. Experience shows that there is a risk of shrinkage and cracks occurring during this process.

B. Recommended Modifications:

In order to minimize the danger of shrinkage and cracking, the following procedures are recommended, using

a specially constructed chamber such as the one illustrated in Figure 1.

1) Better unifomity of results will occur if the chamber containing the wood is quickly brought down to -40°C.

2) After the wood and tert. Butanol are completely frozen, a vacuum of 100 uHg is drawn.

3) While applying a vacuum, the temperature is allowed to gradually rise to room temperature (10°C-20°C) over a period of five to six hours for an object of a matchbox size.

It is believed that the quick and unifom freezing in step 1, and the controlled increase in temperature in step 3 will result in minimal stress to the wood. For this reason, there is a reduced risk of shrinkage or cracks in the treated wood.

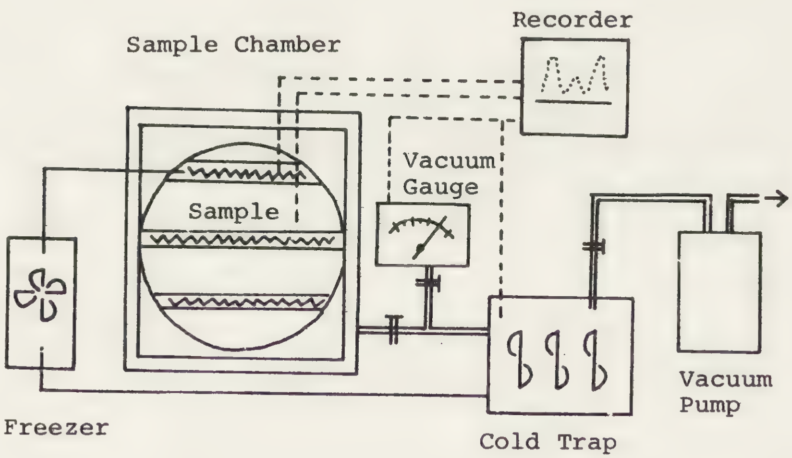

Figure 1. The illustration of freeze-drying apparatus

V. CONCLUSION

The modified procedures for treating water-logged wood discussed in this paper have been used at The Nara National Cultural Properties Research Institute for five years with excellant results. In addition, the continuing popularity of freeze-drying among many specialists of water-logged wood is evidence of the success that conservators have obtained with this technique. It is believed that the above outlined improvements will further serve to demonstrate the importance and usefulness of freeze-drying for the treatment of water-logged wood.

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81/7/5

DESIGN OF A LARGE-SCALE PEG TREATMENT FACILITY FOR THE BROWN'S FERRY VESSEL

Katherine R. Singley

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Working Group: Waterlogged Wood

DESIGN OF A LARGE-SCALE PEG TREATMENT FACILITY FOR THE BROWN'S FERRY VESSEL

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Abstract

A facility for treating large-scale timbers with polyethylene glycol currently is under construction in Columbia, South Carolina. When operating, it will be the largest facility in North America. The installation first will be used to treat the Brown's Ferry Vessel, an American merchant vessel of the 18th century, in one piece. This paper outlines the project and the design of the system, which incorporates a 56-foot tank. Unfortunately, because of space, only basic features could be discussed. Suppliers are cited at the end of the paper.

Introduction

In the fall of 1979, the Institute of Archeology and Anthropology of the University of South Carolina was awarded $300,000 with which to build a polyethylene glycol (PEG) facility for treating large-scale waterlogged timbers. The funds were awarded jointly by the National Trust for Historic Preservation and the legislature of the state of South Carolina. The facility first will be used to treat the 48-foot Brown's Ferry Vessel, recovered in 1976, to date the oldest vessel recovered from American waters. The treatment cycle will begin in the spring of 1981. While the Brown's Ferry Vessel will be treated in one piece, the PEG tank and system are designed with as much flexibility as is possible so that components can be modified to treat other large timbers and wooden artifacts in the future.

The design combines features of established conservation facilities in Sweden, the Netherlands, England, and Canada. The treatment with the closest parallels to that proposed for the Brown's Ferry Vessel is, of course, that of the Cog of Bremen (Mühlethaler, 41-44). Ideas on design and compatabilities of materials put forth by Barkman

et al (1976), Blackshaw (1975), Murdoch (1978), Christenen (1970), and Gregson (personal communication, 1977), were considered. However, because of the size of the facility and financial constraints, the ideal materials and components could not always be selected. It is hoped that the proposed design strikes a balance between economy, durability, and flexibility.

The Brown's Ferry Vessel

The Brown's Ferry Vessel was recovered from the Black River in eastern South Carolina in 1976. It is a cargo vessel dating from 1735-1740, a fine example of the commercial shipbuilding which must have existed, though largely undocumented, during the colonial period in the southern United States. In addition, all the woods used in constructing the Brown's Ferry Vessel are southern, further pointing to a regional tradition of ship construction. The 36-foot keelson is a single piece of baldcypress (*Taxodium distichum*). The planking is a variety of yellow pine, while some frames are white oak and the bow stem live oak. (In the latter cases, complete identification was hampered by the state of deterioration of the wood.) Some patches of caulking and sealant, probably pitch, are evident; samples will be analyzed.

By carefully examining the remaining timbers, Mr. Richard Steffey, of the Institute of Nautical Archaeology at Texas A & M University, constructed a scale model of the vessel in 1977. His reconstruction shows a double-ended merchant vessel with two masts and with small decks possibly at the bow and stern. It has no keel and is flat-bottomed. With its shallow draft, estimated about a foot of freeboard if totally loaded with 25 tons, the Brown's Ferry Vessel was designed to maximize open cargo space. Further details of the construction of the Brown's Ferry Vessel are provided in Albright and Steffey (1979).

A craft like this one recovered at Brown's Ferry on the Black River would have been the work horse of transportation in the colonial plantation economy. It would have carried settlers and supplies, imported and domestic, inland, and would have carried timber, naval stores, and cash crops like indigo downstream to the urban centers of Charleston and Georgetown. As a carrier of cargo, the Brown's Ferry Vessel was designed to serve in waters of varying degrees of navagability. It could have been beached easily, or poled through shallow backwaters, or sailed in open waters close to shore.

The Treatment Plan

Since its recovery in 1976, the Brown's Ferry Vessel has been kept wet by either spraying or re-immersion in a secure freshwater pond. The original environment, the heavily tannated Black River, contributed to the excellent preservation of the boat. However, some degradation has occurred in the series of changing environments

during the four-year period. Renewed microbiological attack has been especially noticeable during the immersion in the pond. An analysis of pond water is underway.

Because of the dimensions of the boat (48 feet long and 12 feet wide at midships), the volume of wood (approximately 225 cubic feet), and the varied species present, it was decided to use a polyethylene glycol (PEG) treatment. Furthermore, it was decided to treat the Brown's Ferry Vessel in one piece, despite the high cost of the volume of PEG solution needed. Because 70% of the boat had been recovered intact, it was felt that dismantling the Brown's Ferry Vessel, tightly constructed with treenails and some large spikes, would have caused more damage.

The grade of PEG proposed for the treatment is Union Carbide 1450*, with a molecular weight of 1300-1600. This grade is regarded as a compromise for the various species and conditions of individual pieces. The oak, of course, is difficult to penetrate, while the yellow pine is quite soft. Those pieces needing further application of a higher grade of PEG, used more like a consolidant, will be treated with a 30-40% solution of PEG 4000 applied by hand during drying. The exact water contents of the various woods are not available at the time of writing this preprint. A systematic sampling of the woods will be made just before immersing the Brown's Ferry Vessel in the tank.

Because of the size of the tank and the limited budget, certain allowances in the treatment must be made. Many of the pre-treatments developed on smaller pieces of wood cannot be done here. Because of the volume of solution and toxological problems, no fungicide can be used. Nor can there be any pre-treatment with acid. It is hoped that a two-month period of intensive washing, in which the temperature of the water will be raised to 60°C before introducing the PEG, will flush out foreign matter and kill micro-organisms. One hundred percent PEG 1450 then will be introduced gradually, raising the concentration of the treatment solution by 1% (w/v) every two weeks to a final concentration of 60%. The temperature of the solution will remain constant at 60°C.

It is felt that the second stage of treatment, a closely monitored controlled drying, will be more critical than the PEG bath. This stage also will take about 2 years. During this period the

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*In May, 1980, Union Carbide polyethylene glycol (PEG) 1540 was renamed PEG 1450. Polyethylene glycol, with a generalized formula of $HOCH_2(CH_2OCH_2)_nCH_2OH$, is a polymer of ethylene oxide. The "n" represents the average number of oxyethylene groups. The number of the Union Carbide grade corresponds to the average molecular weight of that grade. PEG 1450 is a soft wax with a melting range of 43-46°C.

Brown's Ferry Vessel will be dried slowly under tension in a more elaborate cradle system.

Treatment Tank (1-7)

In order both to lower construction costs and to have access to plumbing, it was decided to build a large treatment tank (1) above ground. The internal dimensions of the tank are: length, 56 feet; width, 15 feet; and depth, 8 feet. It has been constructed using poured-in-place concrete with steel reinforcing rods. The concrete mix has a strength of 3,000 p.s.i. in 28 days. The walls of the tank are 10 inches thick, and there is a 6-inch slope along the bottom of the tank to facilitate drainage. The contents of the tank will be pumped over the side. When filled to within 6 inches of the top, the treatment tank will have a capacity of approximately 50,400 gallons. The internal walls have baffles for subdividing the tank in the future.

A lining system (2) has been applied to the tank's internal surface in order to prevent inorganic matter from being leached from the concrete during the treatment cycle. Access holes for piping also have been coated. After the surface of the concrete was sandblasted, a primer of epoxy, 10 mils in thickness, was applied. This was followed by a 100-mil layer of polyester (Reichold 33402) with 25% fiberglass mat (1½-ounce weight, silane finished). A one-ply coating of veil and more resin then followed. Finally, a topcoat 10-20 mils thick of parafinated flakeglass was applied, to give a total thickness of about 125 mils for the lining system.

A lightweight, insulating top (3) for the treatment tank has been designed to be removable. Fourteen arched sections (each 4' x 15' 10", with an arch 18 inches high) of fiberglass and polyurethane foam have been constructed to be self-supporting. Each section weighs about 170 pounds. Three windows (1' x 1') with sliding covers have been provided for controlling evaporation. The sections overlap to insure a tight fit. A felt and silicone gasket seals each section of the lid to the wall of the tank.

The tank is equipped with a 5-foot gauge glass for visually inspecting the liquid level and two dial thermometers (4), H.O. Terice V80361, for monitoring the temperature of the PEG solution at depths of one foot and four feet. Each thermometer has a range of 30-240^{o} F and a probe made of 316 stainless steel. Two safety floats (5), Penn F63BF, are included, one to trip the circulation pump should the PEG solution fall below a set level, and the other to open the main water line to maintain a constant volume of PEG solution. At one foot from the bottom of either end a suction header (6) is placed to withdraw the circulating solution. Each header has a diameter of six inches and a series of 1-inch nozzles along the 15-foot length.

The tank is insulated by a 2-inch thickness of blown polyurethane foam having a density of two pounds and an R value of 14.3.

Circulation System (7-11; and 17)

The PEG solution is circulated through Orion polypropylene "Blueline" piping (7), schedule 40 with a diameter of 3 inches. The sections are linked by socket weld fittings, in which the pipe is heated and fused. The pipes will be insulated with jackets made of high density fiberglass, 1½ inches thick.

A centrifugal circulating pump (8), Armstrong model H67-HB, is placed in-line to circulate the PEG solution. The pumping capacity is adjustable, with a minimum of 70 gallons per minute at the 30-foot (13 p.s.i.) head of pressure in the lines. The pump has a bronze body and impeller, a 316 stainless steel shaft, and a ceramic shaft seal.

In theory, the volume of PEG solution in the tank should be circulated every twelve hours. A flow indicator made of stainless steel (9), Metraflex Model 13, displays the gallons per minute. A flow switch (10), Penn F61MB, stops the circulating pump if flow is not detected. The circulating PEG solution enters at one end near the top of the tank and is pulled out at the opposite end near the bottom. Additionally, the flow of the PEG solution is reversed every 12 hours by manually tripping four motorized flow valves (17) to open and close in pairs. The single seat, two-way globes valves (Penn V90AA) have diameters of 2 inches and brass bodies with 316 stainless steel trim and stems.

An industrial filter unit (11), Dollinger model LL242-114, is placed just after the pump to remove particulate matter greater than 5 microns from the flow lines. It is felt that its placement before the pump would diminish the pull of the pump. The filter unit is comprised of a 304 stainless steel housing and a removable cotton filter (92BN4N3). The filter has 11.4 square feet of surface area. The filter must be able to handle temperatures up to 200^{o} F as well as the 70 gallons per minute at a 30-foot head required. Should the pressure in the flow line build as a result of a clogged filter, a pressure switch will trip a motorized valve (identical to the four Penn valves above) to open a by-pass line around the filter unit. Finally, the filter unit may be isolated from the flow line for cleaning and maintenance by manually closing two gate valves.

Heating System (12-13)

The PEG solution is heated as it continuously flows through a heat exchanger (12), Armstrong S-85-2. The heat exchanger consists of a removable series of 3/4" copper tubes surrounded by a shell of sheet steel into which steam is piped. The copper tubing provides 42.4 square feet of surface area. A two-way proportioning steam valve (Penn V90AA) controls the amount of steam entering the heat exchanger. The system will operate up to a pressure of 150 p.s.i.

The steam will be generated by a natural gas boiler (13), Peerless model 211-7 SP. The unit has an output of 1,000,800 BTU per

hour. It is equipped with numerous safety valves, including a cut-off valve for low water. A pump also is provided for returning the condensate from the heat exchanger to the boiler.

PEG Dispensing System (14-16)

The volume of PEG solution needed to treat the Brown's Ferry Vessel has affected greatly the design of the chemical dispensing system. It is well established that PEG is more successful if introduced gradually, often by increasing the concentration in the solution by about 1% every two weeks. This increases in turn means that each day about 25 gallons of molten PEG 1450 must be added to the treatment solution. A dispensing system has been designed to be flexible, providing a way to melt the PEG without excessive handling.

PEG 1450 is dispensed into the system directly from 55-gallon drums. The molten wax is pumped from one drum while a second is being heated. Chromalox drum heaters (model PFDT) are placed around both drums. The 1500 watt heating elements have built-in thermostats that may be adjusted. Additionally, insulation blankets (Chromalox PCN263011) made of neoprene rubber and fiberglass are wrapped around both drums (14).

A diaphragm metering pump (Neptune 532-S-N4) is used to dispense the PEG (15). The pump has a ¼ horse power motor; the flow may be adjusted from 0 to 11.2 gallons per hour. Components of the pump are no. 20 stainless steel. A thermostatically controlled tape and an insulating jacket, similar to those for the drums, keep the pump warm.

A flexible stainless steel hose (Flexonics series 400L) provides a movable link to the 316 stainless steel 3/4" feed pipe (16). As one drum is emptied, the hose is removed and attached to the next drum. Chromalox electic DLR heat tape, providing 14 watts per foot, is placed on the pipe as well as on the dispensing pump. Both lengths of tape are individually controlled by Chromalox industrial thermostats (model AR-2524P) with a temperature range of 50-250° F. Fiberglass insulating material for piping will be wrapped around the pipe. A back pressure valve set at 50 p.s.i. is placed on the dispensing line.

Finally, a low limit thermostat is inserted into the base of each drum. The dispensing pump stops if the temperature of the wax in the drum falls below a set point.

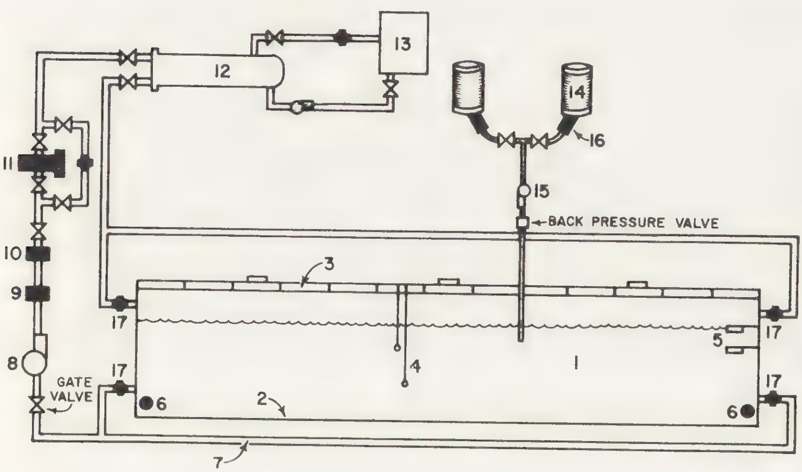
Anticipated Problems

While the utmost effort was made in designing the facility to prevent problems in its operation, certain difficulties are bound to occur. A test run will be made before immersing the boat to check the plumbing and circulation and to calibrate the pumps. Pockets of uneven temperature and concentrations may exist along the 56-foot

length. More thermometers and secondary agitators may have to be installed. The filter element selected may have to be replaced by another which better meets our needs.

The system will require monitoring once every twelve hours to change the direction of circulation. The temperature, velocity of flow, and dispensing system will be checked twice a day. Drums and their heating devices will have to be rotated every two days for dispensing PEG. Specific gravity readings will be made once a week. A control panel contains a switch to change the direction of circulation, a light to indicate the use of the by-pass line around a clogged filter, and a modulating switch to control the amount of steam entering the heat exchanger.

Despite the size of the installation, the design does have flexibility. The pumps, filter unit, and piping all can be dismantled. The tank can be subdivided into smaller units. Once problems are rectified, the installation will provide a base for future projects in conserving waterlogged wood on a large scale.



Simplified diagram of the PEG system (not to scale)

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Suppliers

concrete treatment tank (1)	Kahn-Lockwood Construction Columbia, S. C. 29201
fiberglass liner system (2) and sectioned top (3)	International Reinforced Plastics Denmark, S. C. 29042
thermometers (4)	H. O. Terice Company Detroit, Michigan 48237
polypropylene headers (6) and piping (7)	Orion Fittings Kansas City, Kansas 66110
circulation pump (8) and heat exchanger (12)	Armstrong Pumps, Inc. North Tonawanda, New York 14120
flow indicator (9)	Metraflex Chicago, Illinois 60612
filter unit (11)	Dollinger Corporation Rochester, New York 14692
gas-fired steam boiler (13)	Peerless Heater Company Boyertown, Pennsylvania 19512
drum heaters, insulating covers, thermostats (14)	Chromalox, Edwin L. Wiegand Division of Emerson Electric Company Pittsburgh, Pennsylvania 15208
diaphragm feed pump (15)	Neptune Chemical Pump Company Division of RA Industries Lansdale, Pennsylvania 19446
flexible feed line (16)	Flexonics 200 East Devon Avenue Bartlett, Illinois 60103
level device (5), flow switch (10), flow valves (17), pressure switches and relays	Penn Controls, A Division of Johnson Service Company Oak Brook, Illinois 60521
bronze gate valves	NIBCO, Inc. Elkhart, Indiana 46514

THE TREATMENT OF WATERLOGGED OAK TIMBERS FROM A 17TH CENTURY DUTCH EAST INDIAMAN, BATAVIA, USING POLYETHYLENE GLYCOL

James T.T.Pang

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Australia

Introduction

The Dutch East Indiaman, Batavia, was on her journey from Texel, Netherland to Batavia, the headquarters of her parent company in the East Indies, when she was wrecked in the Houtman Abrolhos, some 50km off the Western Australian Coast on the 3rd June 1629. Commencing in 1973, three hundred and forty-four years later, the wreck site of Batavia (28° 30' S, 113° 45' E) was progressively excavated by the Western Australian Museum over a three year period. Material excavated include several cannon, 27 tonnes of sandstone building blocks, 4,000 silver coins, over 800 pieces of shot, over 30 tonnes of waterlogged wood and several thousands of other small items.

Currently, at the Western Australian Maritime Museum we are conserving over 30 tonnes of waterlogged oak timbers from a huge section of the Batavia's hull; one third of the port side of the vessel, including half of the stern (see fig. 1). This hull section was found intact beneath the seabed and was dismantled completely prior to raising (Green and Pearson, 1975).

The dimensions of the individual timbers vary from as thin as 1cm to as thick as 60cm. The maximum length is over 5m. It is anticipated that the stabilization program shall be completed by late 1986. The timbers will then be put back together to form a display of that section of the Batavia's hull, in the new Western Australian Maritime Museum.

This paper outlines the procedures used in treating these waterlogged timbers, immediately after they have been taken out of their watery grave, to the stage when they are stable, dry and ready to be used to construct the Batavia display.

On-site Conservation and Transportation:

The Batavia wrecksite is over 500km from the Western Australian Museum Conservation Laboratory in Fremantle. Because it is 56km from the mainland, the excavation headquarters were set up on Beacon Island, a small island 3km from the excavation site. The annual rainfall on this island is only 500mm and as a result fresh water may be looked upon as liquid gold.

To stop the timbers from cracking and from irreversible structural damage once they were taken out of the sea, they were kept wet at all times. Near the base on the island a reservior about 2m deep was dug, lined with sand and then with heavy duty plastic. When the timbers were taken off the wrecksite, they were ferried back to the base and unloaded immediately into the reservior filled with sea water. A plastic sheet was placed over the reservior.

A biocide was added to the sea water to retard any biological deterioration in the timbers. The choice of biocides in this application was very much limited by insolubility of most biocides in the sea water due to high salt content. The sodium salts of chlorinated phenols (see fig. 2) such as 2,4,6-trichlorophenol, pentachlorophenol and 2,2' dihydroxy-5,5'-dichlorodiphenyl methane or DDDM are fairly soluble in sea water (up to 5000 ppm).

These chemicals, when used in small quantities (as low as 50 ppm) were found to be effective against a wide range of troublesome microbes, including fungi. However, 2,4,6-trichlorophenol and pentachlorophenol are not only toxic to the microbes but also extremely toxic to the human operator. Because of the very volatile nature of these chemicals and the manual handling of the timbers, they present a health hazard to personnel. For these reasons they were not used. DDDM, with the commercial name of "Panacide", is a lot less toxic to humans and yet effective against microbes and fungi when added to sea or fresh water in small quantities. It has been used on waterlogged timbers and other organic materials and no detrimental effect has been observed on these treated materials for the last decade. "Panacide", which is DDDM dissolved in 5% sodium hydroxide, is currently available from British Drug Houses.

For the long journey (over 500km) back to the Conservation Laboratory in Fremantle each piece of timber, with a small volume of sea water/panacide solution added, was sealed in polythene bags. The timbers were transported by sea. At the Fremantle wharf the timbers were quickly loaded onto trucks and taken to the Conservation Laboratory approximately 2km away.

Conservation in the Laboratory:

Immediately upon arrival at the Conservation Laboratory, all the timbers were washed with fresh water, registration numbers recorded and condition photographed. They were then placed in sheltered storage tanks containing water/panacide solution at room temperature (14-22°C).

Before starting preservation, the timbers were randomly checked and identified as European Oak (Sp. Quercus robur). Because the timbers had been buried in a moderately warm (20±3°C) seabed in shallow (6 metres) water for 344 years (North, 1976), some of them were badly biodeteriorated on the surface but extremely solid in the core. Quite a number of them had been partially exposed above the seabed and showed attack by Toredo worms. The water content of the waterlogged material varies not only from one piece of timber

to another but also with distance from the soft surface to the solid core of each piece. A typical water concentration profile on a piece of Batavia timber is shown in fig. 3.

The method chosen to consolidate the waterlogged timbers was impregnation by total immersion in aqueous polyethylene glycol 1500 solution. Four impregnation tanks, each having a width of 1.5m, a length of 4.0m and height of 1.2m, were constructed out of 5mm thick mild steel and fitted with a removable lid. The tanks and lids were thermally insulated and heated with stainless steel heat exchange pipes containing circulating hot water. Each tank is capable of treating up to 4 tonnes of waterlogged timbers. To increase the diffusion rate of the PEG 1500 molecule into the wood, the impregnation solution was heated to 60°C, a temperature that provides maximum diffusion rate without seriously increasing the thermal degradation of the PEG molecules and the wood fibre. To ensure proper mixing of the PEG solution and at the same time eliminate the accummulation of any harmful gases; the solution was periodically purged with nitrogen from a gas line permanently placed on the bottom of the tank.

To initiate the impregnation process, each timber was recorded and was loosely packed in supported layers in the tank. With a minimum delay the tank was quickly filled with water containing approximately 20 ppm of panacide at room temperature. The water was gradually heated to 60°C at the rate of less than 0.5°C per hour. At 60°C, PEG 1500 was slowly introduced into the solution. Over the next 2-3 years, the percentage of PEG in the solution was gradually raised to 90% (w/w). It is important not to raise the PEG concentration in the solution too rapidly, as this may lead to a sudden increase of osmotic pressure in the timber and cause serious damage. On the other hand, one must remember that the diffusion rate of PEG molecules is proportional to the concentration gradient between the timber and the solution. A slow PEG increase in the solution may be safe for the timber, but requires a longer impregnation period and hence higher costs. To work out a maximum rate that is safe for the timber, it is necessary to regularly monitor the extent of PEG penetration into the timber during impregnation.

Using a 400mm long and 4mm diameter increment borer, random core samples were taken every six months from the timbers for chemical analysis. Each core sample was analysed in 2cm sections for water and PEG content. Water content was determined by the difference in weights before and after drying in a vacuum dessicator over silica gel. In the earlier work, PEG content was determined by the colourimetric method of Shaffer and Chitchfield (1947). This method is tedious and its accuracy is seriously limited by the instability of the colour complex used in the measurement. In later work, all PEG samples were studied by the Infra-red spectrophotometric method, which is fast and accurate. Incidentally, using this method we have obtained evidence of de-polimerisation of PEG molecules in both the solution and the timber. Investigation of the de-polimerisation is currently in progress and the findings will be published in the near future. Going back to the problem of analysis, PEG in the

vacuum dried core sample sections were quantitatively extracted with analytical grade benzene (caution: benzene is a carcinogenic material) over a period of ten days. A potassium bromide cell with constant path-length of 1.0mm was used to obtain the spectra of the benzene extract. Fig. 4 is a series of infra-red spectra obtained from a set of standard solutions with PEG concentrations ranging from 0.0006g ml^{-1} to 0.0223g ml^{-1}.

The absorption peaks at $1105cm^{-1}$ (9.05μ) and $2870cm^{-1}$ (3.48μ) are respectively due to the symmetrical ether carbon-oxygen-carbon bond stretching and the assymmetrical methylene carbon-hydrogen bond stretching of the PEG molecules. As can be seen, the absorption intensity is dependent upon the PEG concentration. A plot of optical density calculated from these peaks against the PEG concentration, as shown in fig. 5, gives two straight lines; both of which may be used as calibration curves for determining unknown PEG samples. It is also found that the calibration curves are independent of the molecular grade of PEG.

In practise, the optical density at $1105cm^{-1}$ (due to the ether bond stretching) is used, because it is not only more sensitive, but it is also relatively free from signal interference due to the organic impurities extracted from wood. Samples extracted from untreated wood gave a blank reading at $1105cm^{-1}$.

We have recently completed the PEG impregnation of a large piece of Batavia timber (0.3m x 0.6m x 4.5m). After more than two years of immersion in PEG solution at 60°C, it looks as good as it was the day it was placed in the treatment tank. (see fig. 6) Table 1 below gives a brief summary of some of the results of PEG analysis of the solution and the timber during the course of impregnation.

From the table, it can be seen that during impregnation, PEG in the solution was deliberately increased at a rate such that the weight ratio of PEG/water in solution was never more than 20% greater than that in the timber. It was observed that the rate of PEG penetration in the timber was extremely slow in the last six months of the process, when PEG concentration in the solution exceeded 80%. This is probably due to high solution viscosity and small amount of free water left (less that 10% based on dried wood) in the timber to take part in counter-diffusion with the PEG molecule

When the decision had been made to take the timber out of the treatment tank for the de-humidification, the temperature in the tank was lowered at a rate less than 0.5°C per hour to 32°C. At

this temperature, the 91% PEG solution was in a semi-liquid state. The tank was kept at this temperature for approximately 1 week, to make sure that uniform temperature had been reached throughout the bulk of the timber. This was done as a precaution to avoid possibl timber cracking due to sudden differential heat expansion when exposed to a lower room temperature. As soon as the timber was taken out of the tank, it was immediately placed inside a de-humidi fication chamber specially constructed for this purpose. Inside the chamber the temperature of the timber was further lowered to ($5\pm0.5^{\circ}C$) and the relative humidity of the chamber was kept at ($90\pm5\%$). A coat (approximately 2mm thick) of PEG 6000 was applied to the surface of the timber. Over the next six months the tempera ture and the relative humidity were slowly altered to ($22\pm0.5^{\circ}C$) an ($55\pm5\%$) respectively, to meet the conditions used for display. Through the use of lower initial temperature in the de-humidificati we found less cracks and shrinkages than in previous experimental trials where temperature varied between 18-35°C. After three month of de-humidification of this large piece of timber we recorded shrinkages of 2% radially, 3-4% tangentially and less than 1% longi tudinally. The result up to this stage has been very encouraging and this may be attributed to a combination of the following factor

(1) During the impregnation, a moderately high temperature (60°C) was used to accelerate the rate of PEG penetrating into the wood.

(2) A long impregnation time (over two years) to allow proper penetration of PEG into the wood.

(3) Chemical analysis of PEG in the wood was carried out periodically to make certain that proper PEG penetration in the wood had been achieved during the impregnation.

(4) A high final PEG concentration (91%) had been used to force more PEG into the wood thus improving the consolidation proces

(5) During the course of conservation, the timber had not been subjected to any shock treatment, such as sudden change in temperature, PEG concentration, relative humidity etc.

(6) Low temperature (5°C) used initially in the de-humidification chamber immobilised the PEG inside the timber, thus minimising the possibility that PEG may be lost from the timber by leaching.

It will be at least another three months before the completion of the de-humidification process. Progress of this will be reporte in September 1981, during the conference in Ottawa, Canada.

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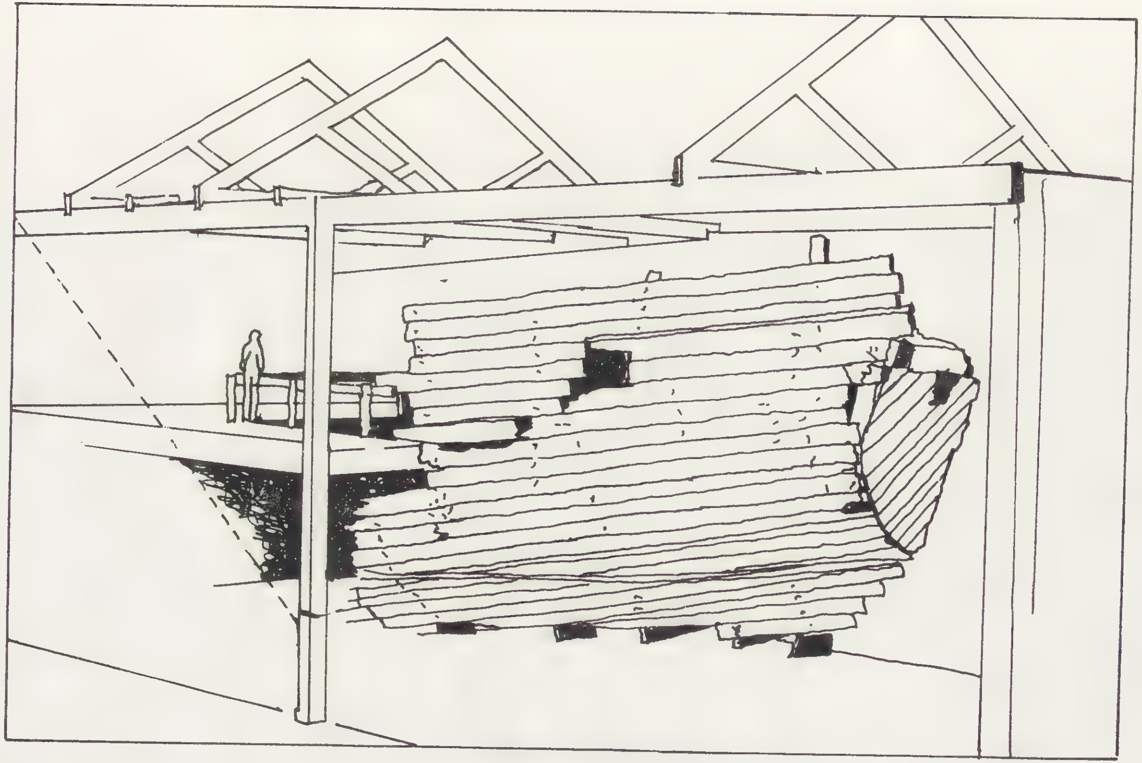
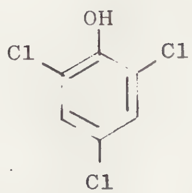
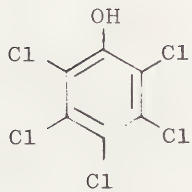


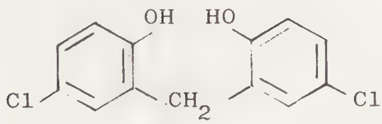
Fig. 1 A scaled-down model of the proposed Batavia hull display



2,4,6-trichlorophenol
(LD$_{50}$ orally in rat: 820mg/kg)



pentachlorophenol
(LD$_{50}$ orally in rat: 180mg/kg)



DDDM. "Panacide"
(LD$_{50}$ orally in rat: 1200mg/kg)

Fig. 2

Some commercially available biocides

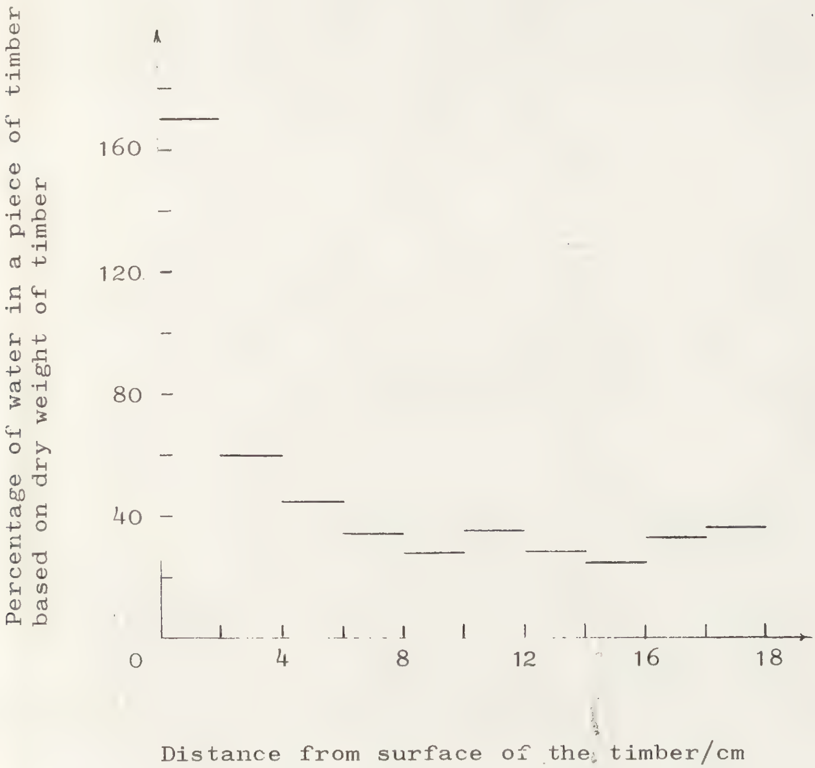
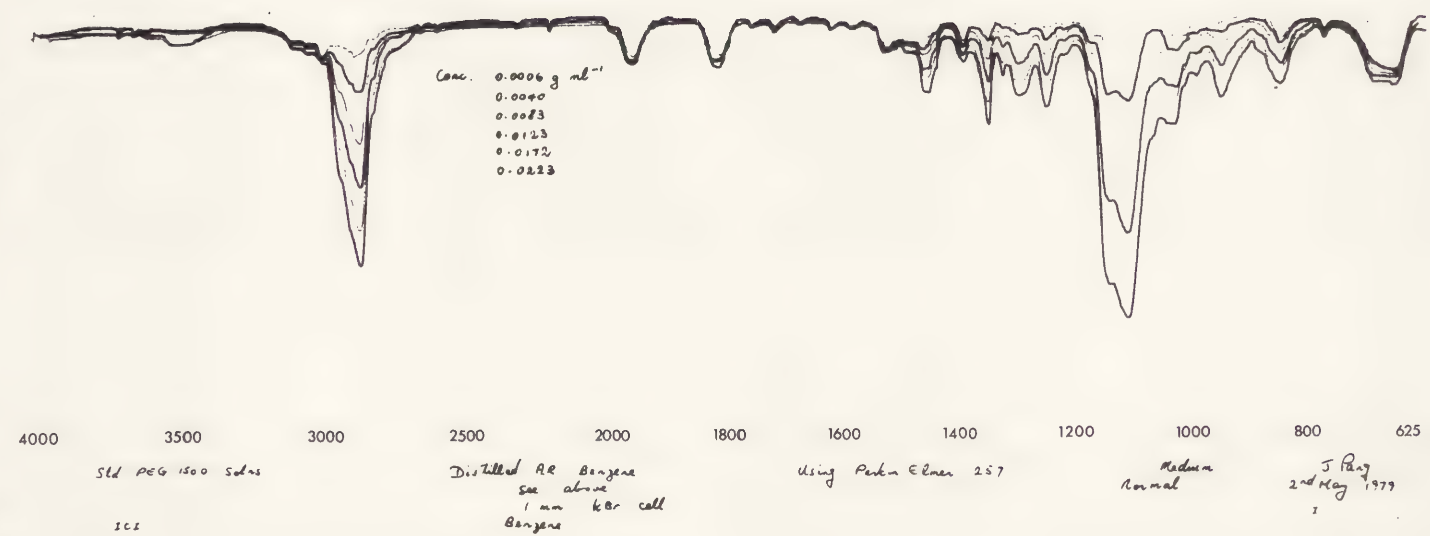


Fig. 3 Water concentration profile in one of the solid Batavia timbers



<u>Fig. 4</u> Infra-red spectra of standard PEG solution

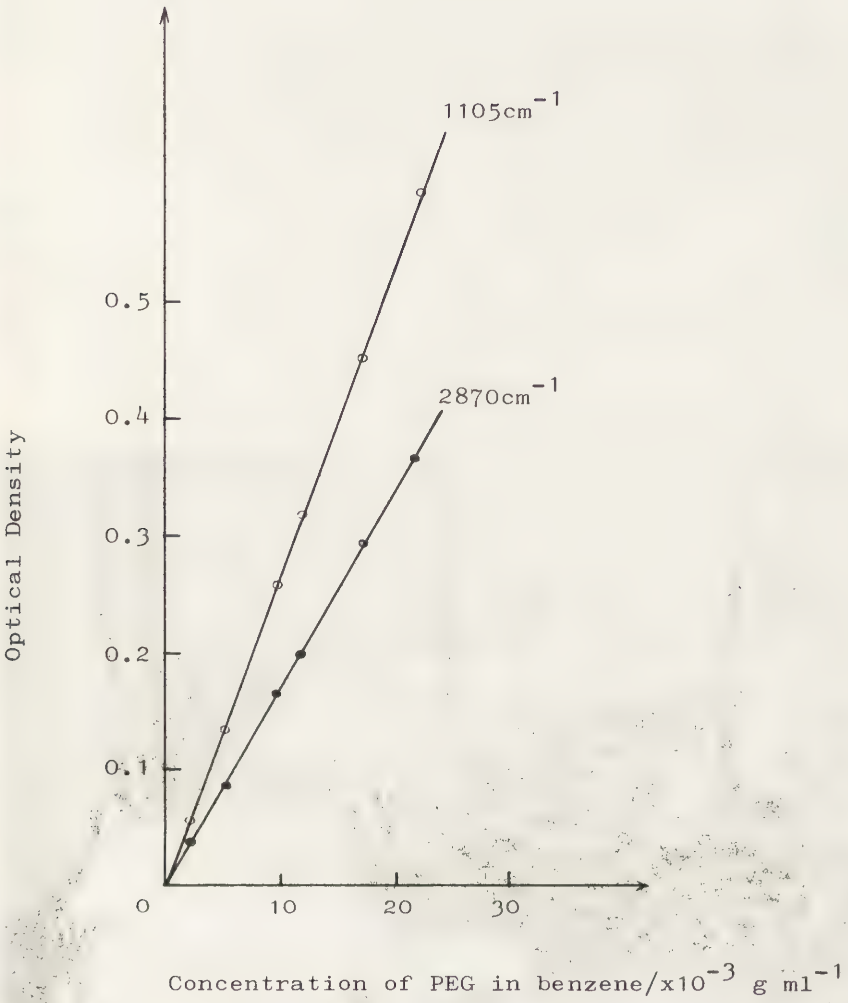


Fig. 5 PEG Standard Curve
Infra-red optical density vs PEG concentration

Fig. 6 A large piece of timber impregnated with PEG is undergoing de-humidification.

Date	PEG/water ratio in impregnation solution	Core sample section distance from timber surface/cm	Weight of dried core sample section/g	PEG/water ratio in core sample section
1st Nov 78	10/90	0 - 2	0.2140	0.0134/0.1204
	(=0.1111)	2 - 4	0.2102	0.0123/0.1103
		4 - 6	0.2306	0.0124/0.1120
(due for further PEG increment in the tank)		6 - 8	0.2451	0.0120/0.1064
		8 - 10	0.2447	0.0102/0.1008
		10 - 12	0.2710	0.0122/0.1000
		12 - 14	0.2942	0.0100/0.0901
		14 - 16	0.3075	0.0104/0.0921
		16 - 18	0.3970	0.0106/0.0901
				(Ave = 0.1123)
4th Sept 79	45/55	0 - 2	0.2092	0.0780/0.0958
	(=0.8182)	4 - 6	0.2344	0.0746/0.0900
		8 - 10	0.2571	0.0650/0.0850
(due for further PEG increment in the tank)		12 - 14	0.2749	0.0642/0.0820
		16 - 18	0.3012	0.0601/0.0750
				(Ave = 0.7984)
17th Sept 79	50/50	0 - 2	0.2002	0.0776/0.0921
	(1.0000)	4 - 6	0.2406	0.0742/0.0892
		8 - 10	0.2600	0.0760/0.0890
(5% PEG increment in the tank a few days before)		12 - 14	0.2649	0.0642/0.0802
		16 - 18	0.2901	0.0601/0.0790
				(Ave = 0.8179)
1st Nov 80	91/9	0 - 4	0.3355	0.1778/0.0182
	(=10.1)	4 - 8	0.3210	0.1602/0.0158
		8 - 12	0.3305	0.1240/0.0128
(Prior to the removal of timber from the tank)		12 - 16	0.3316	0.1190/0.0218
		16 - 18	0.3270	0.0998/0.0120
				(Ave = 8.6743)

TABLE 1

81/7/7

EXPERIMENTS WITH SUGAR IN CONSERVING WATERLOGGED WOOD

G.H.Grosso

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Waterlogged Wood

EXPERIMENTS WITH SUGAR IN CONSERVING WATERLOGGED WOOD

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Abstract

Described is an experimental application of the sucrose method of conserving waterlogged wood utilizing 40% (v/v) sugar solution at room temperatures. Results are reported using several additives to the sugar solution with superior results noted with ascorbic acid. Growth of organisms in and on the test solutions is described. Comparison of results with the polyethylene glycol Carbowax 540 Blend is given.

Introduction

Conservation of waterlogged wood has been a formidable challenge for the conservator for many years. This is increasing on a worldwide basis, partly because of the successes achieved by many conservators in dealing with the problem, and partly because of improved archaeological techniques which make excavation of water-saturated sites more feasible. Conservators, then, are facing more of the waterlogged wood objects and larger objects as the archaeologists become increasingly ambitious. The pioneering work by Barkman in attempting the treatment of a virtually complete ship with polyethylene glycol is a work of heroic proportions which certainly has resulted in acceptance of the idea that objects of Wasa size can be considered for conservation treatment.

Variations of the polyethylene glycol method are legion with practitioners using PEG of various molecular weights. The solvents used vary considerably. Apparatus for the treatment ranges from simple, watertight containers of wood lined with plastic sheeting to complex stainless steel tanks replete with heat exchangers, circulating

pumps and automated replenishment systems. Whatever the method, this remarkable chemical (PEG) generally does the job.

But it is not perfect. It leaves treated wood several tones darker in color than natural wood (though this can be mitigated somewhat by surface cleaning after treatment.) The chemical itself is somewhat expensive. It is not readily available in some parts of the world. And, most importantly, it doesn't always work perfectly.

For these reasons, and because of the natural curiosity of man, alternative processes are sought, devised and tested. These include impregnation with resins, both natural and synthetic; various freeze-drying techniques; air drying, and impregnation with sucrose, to list a few.

The latter method, sucrose impregnation, is the subject of this preliminary report. Results of experiments with sucrose treatment were reported by Barkman (1) at the Neah Bay Conference in 1976. Jedrzejewska at Zagreb in 1978 (2) challenged conservators working with waterlogged wood to perfect a reasonable alternative to the PEG method. As a result, a working group was formed to conduct experiments with the sucrose method. The part of the project described in this paper involves the practical application of the method.

Problem

Sucrose has been indicated as an agent capable of stabilizing waterlogged wood. A technique of utilizing this capability in a simple, inexpensive, safe and reliable manner must be devised.

It can be shown that there are many techniques which are quite successful when applied in the laboratory on very small samples under carefully controlled circumstances. While this may be satisfactory in the theoretical world, the real world of archaeology oftentimes finds the conservator working in a difficult environment with few facilities, little help and a budget of crumbs from the expedition's monetary cake.

The technique for use of the sucrose method, then, must be one suitable for application in the real world.

Experimental Method

Granulated table sugar was selected as the sucrose

source. The particular sugar utilized in the experiment is beet sugar manufactured by the U and I company of Salt Lake City, Utah. Retail price for granulated table sugar in the U.S. Pacific Northwest in February, 1981, ranged from $11.49 to $13.09 for 25 pounds (113.25kg). Sacks of 100 pounds (453kg) were available for $44.22.

The philosophical approach to this experiment was to develop a method applicable to field conditions. A test solution concentration of 4 parts sugar in 6 parts hot tap water was decided upon. Readily available additives were selected with the aim of eliminating or attenuating unwanted biological activity in the treatment baths. A quantity of one-quart glass jars was assembled to give the containers for processing. Samples of waterlogged wood of various types and ages were obtained.

First, the jars which formerly contained mayonnaise or salad dressing were washed with hot water and household dishwashing detergent, rinsed with hot water and allowed to air dry.

Then the 40% (v/v) sucrose solution was prepared in a plastic bucket. Ten of the jars received 750ml of the sugar/water solution.

Additives chosen were formaledehyde, potassium chrome alum, potassium metabisulfite, borax, ascorbic acid and sodium chloride. Concentrations were added as follows:

Test solution 1	3.75ml 37% formaldehyde
Test solution 2	3.75g potassium chrome alum
Test solution 3	0.375g potassium metabisulfite
Test solution 4	0.75g potassium metabisulfite
Test solution 5	3.75g potassium metabisulfite
Test solution 6	7.5g potassium metabisulfite
Test solution 7	7.5g borax
Test solution 8	7.5g l-ascorbic acid
Test solution 9	7.5g sodium chloride

Test solution 10 received no additives. Test solution 11 was 750ml of 50% (v/v) aqueous polyethylene glycol Carbowax 540 Blend. Test solution 12 consisted of 750ml tap water treated with 4.5g borax and 10.5g boric acid.

Each of the jars was numbered and labeled and placed in a cluster on a work counter in the laboratory.

Several samples of waterlogged wood were selected from the holding tanks (water treated with 0.6% borax (w/w) and 1.4% boric acid (w/w).)

The first wood sample, arbitrarily designated with the

letter A, was sawn into pieces about 4cm in length. Though the sample was not of regular shape, the test pieces ranged from 1.54cm to 2.02cm in thickness. In width, the test pieces ranged from 3.56cm to 4.64cm. Length equals longitudinal orientation of the grain, thickness is the radial dimension and width is the tangential measurement.

Sample A is a 14,000,000-year-old hardwood, very likely related to the pecan hickory (Carya sp.) of today. The specimen used is a portion of a sizable tree fragment recovered during tunnel work in the Columbia Basin of the State of Washington. It has been identified as *Carya tertiara*, an extinct Miocene species (3).

Sample B, a piece of softwood charred on one side, was cut into test pieces about 2cm in length. Though this sample also was of irregular cross section, the test pieces were roughly 4cm in the tangential dimension and a similar measurement in the radial.

Sample C, a length of cane-like stem of slightly more than 1cm in diameter, was cut into pieces about 1cm in length.

Sample D, a splint of softwood of roughly triangular cross section with measurements ranging around 1cm in the radial dimension and around 1.2cm tangentially, was cut into pieces about 1cm in length.

The latter three samples are from the Ozette Archaeological Project and had been buried in a wet environment for approximately 500 years. Barbour (4) identifies Samples B and D as Sitka spruce (*Picea sitchensis*). Sample C is Salmonberry (*Rubus spectabilis* Pursh).

Each test piece was measured, weighed and tagged, then a piece from each of the Samples placed in one of the 12 jars of solution.

The jars were left uncovered at room temperature and observed periodically for 136 days, at which time the test pieces were removed from the solutions, given a brisk, brief rinse in hot tap water, measured, weighed and placed on an elevated plastic-covered fiberglass screen of about 1mm mesh to air dry.

After four weeks of air drying, the test pieces once more were measured and weighed. Changes in dimensions and weights between the wet samples at the start of the treatment and after air drying were computed.

Results

Observations during the period of immersion in the 40% sucrose solutions, the 50% PEG solution and in the treated water holding solution showed no obvious trauma.

Interesting biological activity was noted in several of the solutions during the immersion period:

Solution 1 was basically clear throughout the test period. Some particulate matter, likely airborne dust particles, was noticeable on the surface.

Solution 2 was a deep purplish blue color with a number of translucent to transparent colonies in suspension. A few colonies of growth were on the surface of the solution.

Solution 3 was cloudy with some translucent colonies adjacent to the wood sample pieces. The surface had three furry circular colonies in white and one dark.

Solution 4 was cloudy but less than number 3. A few translucent colonies were noted in suspension. The surface was virtually covered with growths of organisms in white, blue-green, yellow, red and orange. Many were furry, some had what seemed to be dew drops on their surfaces.

Solution 5 was clear with a slight hint of haze. Its surface was covered with growths as in number 4.

Solution 6 was clear but for many translucent white entities about 1mm in diameter. The surface was generally clear but for particulate matter floating and two tiny (less than 1mm) floating objects.

Solution 7 was clear, yellowish, with translucent colonies in suspension. The surface was covered with furry white and gray-green colonies.

Solution 8 was clear, golden, with some large, translucent colonies suspended in what appears to be a more vertical orientation than previously noted in other solutions. The surface was covered with furry greenish white growths.

Solution 9 was hazy clear with wispy colonies emanating from the wood test piece B-9 and a few similar colonies in suspension. The surface was

covered with gray-green growths, plus a few small colonies of furry yellow growth.

Solution 10 was hazy clear with one large gelatinous appearing white colony plus many smaller ones. Considerable particulate material was noted on the surface.

Solution 11 was clear, light yellow. The surface was clear of growths but had some particulate matter.

Solution 12 was clear, light yellow in color with colonies of growth in suspension and adjacent to the wood test pieces. The surface had several clumps of growths, dust and one dead flying insect.

From superficial appearances, the formaldehyde and the high concentration of potassium metabisulfite are the most successful additives in keeping the solutions in a more or less pristine condition. It should be noted that formaldehyde is the most dangerous additive in the test group. While it appears to be efficaceous, its use is not recommended for safety reasons.

Though the solutions with great growths of mold (?) are quite unsightly, and the mysterious translucent growths (anaerobic bacteria?) in the solutions are disconcerting, their presence in the solutions is not reflected in the appearance of the test pieces after air drying. In fact, the only specimen which showed any splotchiness on drying was B-1 which had been treated in the sucrose solution containing the formaldehyde.

The best appearance after air drying uniformly was achieved in all samples with the ascorbic acid-treated solution. Though the effect was less marked on the 14,000,000-year-old wood, all exhibit warm, natural wood colors.

Percentage of Change in Weight from "Start"
After Treatment and 4 Weeks Air Drying

	Wood Sample by Assigned Letter			
Soln.	A	B	C	D
1	-2.2	-8.8	-12.5	-4.3
2	-2.2	-8.5	-20.0	N.C.
3	-3.4	-8.7	-44.4	-4.3
4	-12.1	-19.4	-44.4	-28.6
5	-19.4	-22.7	-40.0	-28.6

6	-19.8	-23.9	-23.8	-44.4
7	-27.1	-31.5	-52.9	-12.5
8	-24.7	-27.5	-44.4	-20.0
9	-19.2	-23.9	-41.9	-9.1
10	-23.1	-27.1	-46.8	-40.0
11	-18.4	-20.2	-47.9	-12.5
12	-81.0	-82.0	-81.0	-66.7

Percentage of Change in Longitudinal Dimension
From "Start" After Treatment and 4 Weeks Air Drying

	Wood Sample by Assigned Letter			
Soln.	A	B	C	D
1	-1.0	-0.5	+4.1	+2.8
2	-0.2	N.C.	+1.0	+2.6
3	-2.1	+1.0	+2.0	N.C.
4	-2.0	+0.9	+2.1	+0.9
5	-2.1	+0.5	+1.4	+1.9
6	-3.6	+0.5	+3.7	+1.9
7	-3.1	-0.5	+1.0	+1.0
8	-0.2	N.C.	+4.3	+0.8
9	-2.7	-1.0	+1.0	+0.9
10	-1.7	+0.9	+3.2	+3.6
11	-1.0	+0.5	-10.0	+1.4
12	-25.7	-4.7	+1.0	+2.3

Percentage of Change in Tangential Dimension
From "Start" After Treatment and 4 Weeks of Air Drying

	Wood Sample by Assigned Letter			
Soln.	A	B	C*	D
1	-3.9	-1.4	-2.6	+0.8
2	-3.4	-6.0	+1.8	-6.8
3	-1.7	-4.2	-0.9	+1.0
4	-8.8	-6.8	-1.8	-3.4
5	-9.4	-1.4	-1.8	+0.8
6	-10.5	-7.6	-2.6	-0.9
7	-5.0	-1.6	+0.9	+0.9
8	-4.4	-4.6	-0.9	-0.9
9	-11.7	-1.9	N.C.	-0.8
10	-3.6	-3.0	-1.8	-2.6
11	-2.2	-6.7	-1.8	-0.9
12	-45.7	-29.1	-13.4	-9.5

Percentage of Change in Radial Dimension From "Start" After Treatment and 4 Weeks of Air Drying

Soln.	Wood Sample by Assigned Letter A	B	C**	D
1	-8.9	-0.2	-3.8	-1.0
2	-11.7	-0.5	+0.9	+7.6
3	-15.3	-0.7	-2.0	N.C.
4	-22.8	-1.1	-1.0	+0.9
5	-19.9	-0.2	-1.0	+1.9
6	-23.7	-2.3	+0.9	+1.0
7	-29.9	+2.0	N.C.	-1.0
8	-25.3	N.C.	N.C.	-0.7
9	-23.0	-0.2	N.C.	N.C.
10	-9.1	-0.7	-2.0	N.C.
11	-4.1	-2.0	-4.8	-8.2
12	-49.5	-6.2	-14.3	N.C.

Notes: * maximum diameter
** minimum diameter
N.C. no change

Subjectively, the samples of wood treated with Solutions 1 through 11 look like wood, though it must be noted that the very ancient pecan hickory looks like very dark wood. The series treated with polyethylene glycol are darker in appearance, generally, than those treated with the sugar solutions. As mentioned above, the sugar solution to which the ascorbic acid had been added yielded samples with the most normal appearance.

The larger specimens of those which had been allowed to air dry after soaking in water treated with only borax and boric acid are grossly shrunken and somewhat warped. Their appearance is terrible. The smaller specimens showed less radical changes, though the D sample, which is spruce of much finer grain than seen in B, did show checking and warping.

Conclusions

It appears that sucrose impregnation is a useful method for stabilizing waterlogged wood, even under the rather primitive circumstances which might be found in a field laboratory.

The overall appearance of the specimens following post-treatment drying is quite nice. The changes in size are mostly what would be expected, except for the somewhat consistent increase in the longitudinal dimension for all but the very ancient pecan hickory.

The biological activity in and on most of the test solutions probably results from airborne organisms as well as those which may be present in the wood and water. A simple brisk rinse seems effective in removing unwanted residue from the organisms.

Perhaps continued research will find an effective, safe, cheap, readily obtainable biocide with which the solution can be treated to eliminate the biological activity. It may be possible to utilize a carbon dioxide blanket atop the preserving containers to prevent the unsightly surface growths.

Further work needs to be done with ascorbic acid as an additive because of the superior appearance of the wood which results from its use.

Also, there should be some technical studies of the possible side effects of the various additives.

From the point of view of the conservator who has had a great deal of experience with treatment of wood with tons of polyethylene glycol, and some experience with acetone/rosin treatment, the sucrose method has a sizable (and for the worker, an important) advantage in relative neatness. Though sugar solutions do get sticky, there is not the insidious sliminess associated with PEG nor the everlasting sticky pitch and dangerous acetone which is the rule for the acetone/rosin method.

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ON THE CONSERVATION OF WET ARCHAEOLOGICAL WOOD BY INTRODUCTION OF WAXLIKE SUBSTANCES INTO IT

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ON THE CONSERVATION OF WET ARCHAEOLOGICAL WOOD BY INTRODUCTION OF WAXLIKE SUBSTANCES INTO IT

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Abstract.- Shown is the possibility of conserving wet archaeological wood with nonhygroscopic waxlike oligomers of ester type, insoluble in water, but readily soluble in ketones. During treatment the water in the wood is replaced by acetone, the wood is kept in 30% oligomer solution in acetone or methyl-ethyl ketone, the solvent being gradually removed by evaporation. Heating applies for accelerating the process is regulated in such a manner as not to let the articles come to the surface. The increase of temperature at the final step of the treatment above that of the solvent boiling-point aids to remove it from the oligomer melt. The experiments were undertaken on samples of much degraded 8th century wood from Staraya Ladoga excavations (fir, aspen, birch, alder, maple, ash-tree) and archaeological neolithic wood (pine, maple). Polycaprolactone oligomers of 1000-1660 molecular weight were used. Satisfactory results were obtained, their dependence on the kind of wood noted. Anatomical studies showed that polycaprolactone fills the cavities in the wood but is poorly linked with the cell walls. The treated wood is 2-3 times less hygroscopic than that dried without treatment.

The conservation of ancient wooden articles found by archaeologists in moist soil, peat-bogs or in water cannot, to all appearance, be carried out by using one and the same method. The techniques applied necessarily depend on the articles themselves, species of the wood and the degree of its degradation. Most universally, the problem can be solved by the replacement of water and filling the cavities in the degraded wood with inert substances which prevent the degraded wood structure from shrinkage and stabilize the shape of the article. It is because of this that by now some water-soluble synthetic waxes - the polyethylene glycols (PEG), suggested for these purposes in the 1950s, have come to be so widely used. The polyethylene glycols of 1000-4000 molecular weight are directly introduced into the wet archaeological wood in the form of water solutions. Their concentration gradually rises up to the degree necessary for the replacement of water by polyethylene glycol. In view of the diversity of the wooden archaeological objects, it is, however, difficult to define the optimal conditions for carrying out the procedure, as the process of replacement is a diffusive one. The time necessary for the process depends mainly on the size of the articles and ranges from a few weeks up to several years. Keeping the wood in water solutions for a long period of time, particularly under heating, leads to further hydrolysis of its components. The polyethylene glycols of 1000-1500 molecular weight replace water in the wood fuller and faster than PEG 4000, but the former are much more hygroscopic than the latter. The authors who first recommended PEG for these purposes /1/ pointed out the possibility of accelerating the process by introduction up to 50% of ethanol into the solution. PEG permeates much degraded wood more readily than that preserved relatively better. The permeating of sound wood with liquids is aided by the removal of extractive substances (resins, waxes and the like) from cell walls, which is attained by treating it with organic solvents /2/. In connection with this, for little degraded wood a treatment is suggested consisting in preliminary replacement of water in it by teriary butyl alcohol till it forms its azeotrope with water, and introduction of PEG into the same solvent with increasing the concentration up to 50% /3/.

In 1963 a method of conservation of wet archaeological wood with paraffin wax was described /4/. It was applied for treatment of mediaeval wooden objects found in Novgorod. The water in the wood was replaced in succession by ethanol or acetone, benzol and ethanol (or acetone) mixture, by benzol and finally by benzol and paraffin wax mixture (1:1), with subsequent evaporation of benzol at 60°C. The total duration of the

treatment was about 30 days, the biggest objects being I50 cm^3 in volume. As marked by the authors, the treatment of carved objects made of different species of wood, spoons made of maple and ash-tree gave satisfactory results, whereas articles made of birch and pine cracked. This method was not widely adopted because of the toxicity and inflammability of the solvents.

We studied the possibilities of conserving wet archaeological wood with waxlike nonhygroscopic oligomers of ester type, insoluble in water, but easily soluble in ketones. Laboratory samples of polycaprolactone oligomers of I000-I660 molecular weight with the content of hydroxyl groups from 3,4 to 2,05% and viscosity at 60°C from I70 up 298 mPa.s were used. Polycaprolactone (PCL) has the formula

$$H\left[O-(CH_2)_5-\overset{\overset{\Large O}{\|}}{C}-\right]_n-O-(CH_2)_5-\overset{\overset{\Large O}{\|}}{C}-OH$$

It is characterized by good stability to heat, light and hydrolysis. The I000 molecular weight oligomer had a yellowish colour and vaseline consistence; it melted at 25-35°C. PCL I090 is soft white wax melted at 34 - 47°C, PCL I500 and I660 are white waxes, hard and rather brittle, fully melted at 52°C. Our expreimental possibilities were limited by the insufficient amount of the PCL I090, though preliminary experiments with the degraded neolithic pine showed that it must be given the preference. That is why, the mixture of PCL I500 (or I660) with PCL I000 in the wheight ratio 3:I was in main used for introduction into the wood. This mixture, like PCL I090, had a consistence of soft wax. Its density at 20°C was I.I4 g/cm^3, at 80°C - I.04g/cm^3.

Treated were samples of 8th century wet wood found in summer I975 during excavations of an ancient site in Staraya Ladoga, in a layer with a great content of chips and manure at the depth of 200-220 cm. Under it, there were a layer of peat and humus and subsoil (blue clay). The pH of the water extract of the soil at the site was close to the neutral one. Before treatment, the samples were kept for I8 months in water containing 0,2% pentachlorophenol sodium salt. For fir, birch and aspen samples, estimated were the indexes of shrinkage, ash content, the holocellulose content according to Wise /5/ and its average polymerization degree by the cadoxen solutions viscosity measurements /6,7/. The data obtained are given in Table I. Before analyzing the holocellulose content, fir wood was subjected to extraction by ethyl alcohol and ether. 3,5% of extractives were found in it. The data in Table I show that the archaeological wood from Staraya Ladoga is badly degraded, the indexes of its shrinkage are much higher, and the content of holocellulose in it is almost twice as low as in sound wood (accordingly, the lignin

Table I

Physical properties and chemical composition of 8th century wood from Staraya Ladoga

Wood species	Water content, %	Shrinkage, %				Ash, %	Holocellulose, %	Average degree of holocellulose polymerisation	Moisture absorption, %
		radial	tengential	longitudinal	in volume				
Fir	8I,6	I0,5	24,7	I,75	35,5	2,79	39,5	660	6,6
Aspen	9I,6	55,6	60,0	I3,3	85,6	3,I2	38,2	447	9,4
Birch	85,0	38,2	55,2	8,9	75,0	2,60	36,8	440	7,I

Annotations to the Tables:

Drying of samples in Table I was brought to the room-dry state

The content of water in wood is given relative to the weight of wood saturated with water

Moisture absorption of air-dry samples was estimated when the change of the air relative humidity ranged from 45 to 95%

Filling of pores was calculated proceeding from the PCL density I,04 g/cm^3

Table 2

Characteristics of wood samples before and after treatment with polycaprolactone

Wood species	Water content, %	Length of the sample, mm	Weight, g			Degree of pores filling, %	Transvers shrinkage, %	Moisture absorption, %
			before treatment	after impregnation	after drying and cleaning			
Fir	85,5	I20	280,50	248,20	22I,II	72	Nil	2,7
Aspen	89,0	I85	377,20	267,25	233,00	55	I2 (cracks)	2,6
Birch	87,I	I02	89,65	83,55	72,67	75	a crack 7 mm	-
Maple	80,4	I68	I68,84	I49,23	I2I,I2	66	I4	3,5
Ash-tree	83,I	I66	80,95	73,73	65,90	75	7	3,2
Alder	88,5	I40	30,85	29,50	26,93	82	I0 (cracks)	2,7

content is higher). Birch and aspen wood is degraded much worse than fir wood.

For treatment with polycaprolactone some samples of various species of wood were taken. Their characteristics are given in Table 2. An aspen sample in the shape of a small peg, 52 mm in diameter and I85 mm in length, had the greatest weight (377 g) The fir sample - a segment-like chip with a knot - also was rather heavy (280,5 g). The birch and alder samples were parts of small sticks. The shape of the maple article was almost cylindrical, the greatest diameter being 50 mm. The article made of ash-tree was a cylinder with a conical handle, the diameter of its cylindrical part was 30 mm. Both articles were carved out not of the central part of the trunk.

The treatment of the wood was carried out in the following steps:

I. Replacement of water by acetone. The objects were kept in a bath with acetone, the amount of which was 2-3 times as much as the weight of the wet wood. The acetone was changed every I-3 days (3 baths). The replacement was considered adequate if the anhydrous copper sulphate did not turn blue when coming in contact with acetone.

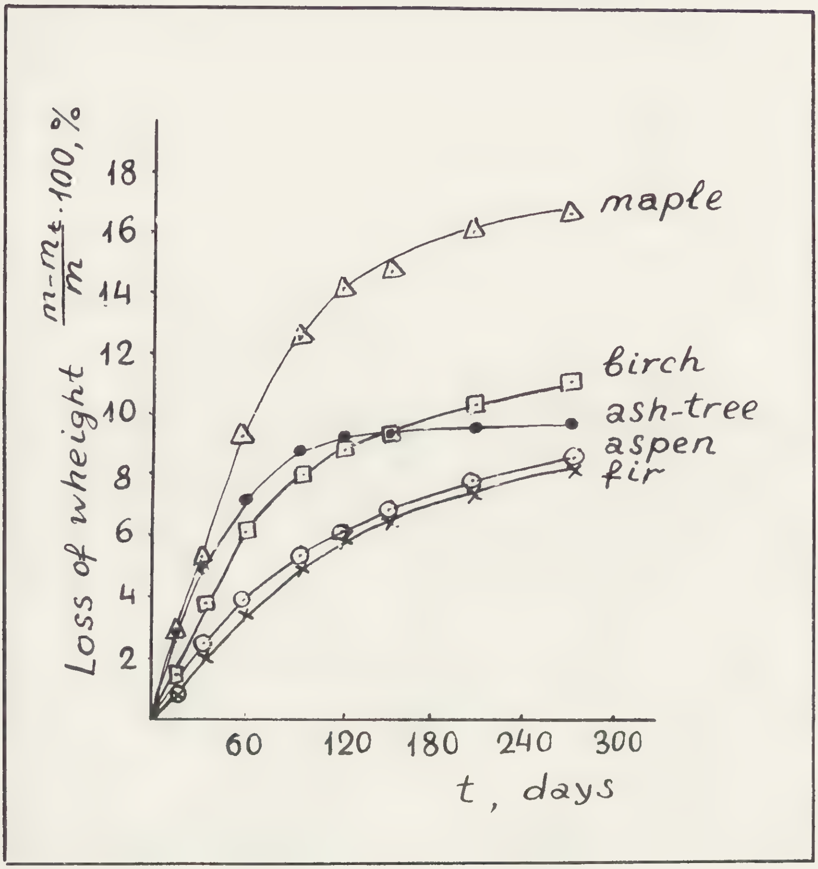
2. Treatment with PCL. The objects from the third acetone bath were put into a 30% solution of the oligomers in methyl-ethyl ketone. At first the objects were kept in a submerged state by force. When the objects do not come to the surface, the concentrations of the solution from the outside of the wood and inside it may be considered equalized. After this, the vessels with the objects were subjected to heating in a water bath under a hood. The heating was carried out periodically during the working day, the evaporation rate being regulated with lids. The heating was stopped when the objects showed a tendency to come to the surface. When necessary, PCL solution of corresponding concentration or pure solvent was added. At the last step, as the vessels cooled down, PCL was observed to be solid, the remnants of the solvent evaporated very slowly even when heated and the solution level practically did not change. The treatment with heating lasted 5 weeks.

3. Drying. The objects taken out of the melt and wiped dry with gauze were kept wrapped up in a polyethylene film during 3 days for slowing down the drying process. As the weight, as a result of such drying, did not change much (0,I - 0,2% in 24 hours), drying was continues without the film. After this, however, radial cracks began to form on aspen, birch and alder samples. On the I8th day of drying, the objects were relieved of the surface PCL excess by dipping them into warm methyl-ethyl ketone and acetone mixture (I:I) and drying with gauze, open drying following. A slow fall in the weight

of big samples was observed in the course of a year. Cracks were developing during the first 3 months. The change of the weight of the samples in the process of drying is shown in the Figure. In Table 2 given are the characteristics of the samples after treatment, the weight after impregnation and after completing the drying, the calculated percentage of filling the volume of the pores with polycaprolactone, the transverse shrinkage, and the moisture absorption of the treated wood when the change of the relative air humidity ranged from 45 to 95%. The treatment proved most favourable for fir. The sample completely preserved its shape and size when the pores were filled with olygomers 72%. Similar results were obtained for two other fir objects of much smaller size, their data not included in the Table. The aspen turned out to be insufficiently impregnated with PCL (55% filling of the pores). A considerable decrease of its wheight after the impregnation is accounted for the fact that this sample was not continually in a submerged state during the procedure.

As a result of impregnation and drying the diameter of the aspen peg showed 12% decrease, radial cracks up to 3 mm wide being formed. Another aspen sample - a stick of a smaller diameter (25 mm) - was treated with more success. It showed 75% filling of the pores and 8% decrease of the diameter with no cracks after drying (not given in the Table). In alder, the filling of pores was 82%, 10% shrinkage across the fibres with the formation of 3 radial cracks up to 2 mm wide. The maple sample showed a rather low degree of the filling of the pores (66%), the highest rate of drying and the greatest degree of shrinkage practically without crackings, but with some deformation. Ash-tree demonstrated a high rate of drying (but a lesser one than in maple). With 75% filling of pores, ash-tree shrinked in diameter about 7%, without forming cracks. It is of interest to note that birch, showing the same high degree of water replacement with polycaprolactone, formed in the process of drying a crack up to 7 mm wide. So, birch, in treatment with PCL, tended to give cracks like in treatment with paraffin wax. The data obtained appear to be accounted for, in many respects, by the peculiarities of the anatomical structure of various species of wood. Thus, birch and maple belong to extremely shrinking species. Relieving the resin passages from resin by treating them with acetone leads, to all appearance, to a successful treatment of fir with oligomers in methylethyl ketone.

On the whole, the shape of the samples was preserved fairly well in leaf-bearing wood species and ideally in fir: the colour of the samples treated is close to the natural one, the objects are hard, but rather



Figure

Change of weight of the treated wood in the drying process

m – the weight of wood after impregnation

m_t – the weight of wood after the expiry of time t from the beginning of drying

brittle. This is also characteristic of the wood treated with polyethylene glycols when a high degree of water replacement is achieved. An atanomical study showed that PCL oligomers fill cavities in the wood tissue, but are poorly linked with the walls and get easily crumbled out of thin sections. As seen from the comparison of the last columns of Tables 2 and I, treatment with PCL does not completely deprive wood of hygroscopicity, but lowers it to a considerable extent. The data obtained led us to the conclusion that in order to make the olygomers permeate wood to the greatest possible degree and to shorten the drying time,a rise of temperature at the last step must be kept much higher than that of the solvent boiling-point. In this case, a fall in the mixture viscosity is observed and the evaporation of the solvent remnants from the melt is facilitated.

Taking this into account, an alder bowl -scoop found in the form of fragments up to I3 mm in thickness was subjected to treatment. The water saturation of the bowl wood was 88,5% of the total weight of the wet wood. In main, the bowl was treated as described above, but periodic heating in the PCL solution was carried out at 75°C till the PCL concentration in the solution reached 60%.Then heating followed at 87°C till the visible stop of evaporation of methyl-ethyl ketone, and finally - at over I20°C during 2 hours. All in all, it took one month to conduct the treatment. Drying in a polyethylene film during two weeks and, after this, without the film for two month resulted in I% decrease of the weight of the bowl. With this, the change of the weight practically stopped. The shape and the dimensions of the fragments were well preserved. They were glued together along the joints with 20% polybutyl methacrylate solution in acetone.

In experiments with badly degraded wet neolithic maple and pine wood, the treatment was carried out with PCL solutions in acetone. To slow down the evaporation, it was conducted at room temperature in a vessel shut not fast till the mixture became solid, heating at 60-70°C followed. The treatment was a success, the pores being filled more than 80%. The pine samples did not change their shape and dimensions, the maple shrank a little.

It should be noted that though the experiments described were carried out in the conditions of free evaporation of the solvent, it is possible to perform the treatment as a periodical process of distillation by utilizing a solvent and seeing to it that the objects do not come to the surface.

Conclusions:
The conservation of wet archaeological wood may be done by introduction into it nonhygroscopic waxlike, soluble in ketones olygomers of ester type, such as polycaprolactone, after preliminary replacement of water in wood by acetone. Such treatment guarantees good preservation of the shape and size of coniferous wood, but can lead to some cracking and shrinkage of objects made of leaf-bearing species of wood. Reduction of the wood hygroscopicity is a positive result of the treatment.

Treatment with polycaprolactone takes less time than the one with polyethylene glycol solutions, but the latter method is simpler, it requires no inflammable and toxic solvents, the link between the filling substance and the wood cell walls is stronger.

The waxlike substance, due to its ability to fill well the cavities of badly degraded wood, imparts brittleness to the wood which is characteristic of the substance.

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ANALYSES OF DIFFERENT STATES OF DETERIORATION OF TERRESTRIAL WATERLOGGED WOOD - CONSERVATION IMPLICATION OF THE ANALYSES. A REVIEW

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Working Group: Waterlogged Wood

ANALYSES OF DIFFERENT STATES OF DETERIORATION OF TERRESTRIAL WATERLOGGED WOOD - CONSERVATION IMPLICATION OF THE ANALYSES

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Abstract

It is recognized that analyses of waterlogged wood must be done for valid research or conservation treatment. The dearth of such analyses is probably due to the overwhelming variable nature of the material and the complicated conservation implications of the analyses. A review of the chemical, physical and morphological changes due to deterioration in waterlogged wood is presented. An attempt is made to point out the conservation implications of these changes.

Reduced amounts of alphacellulose causes increased adsorbency and cell wall shinkage. Chemical changes of cellulose cause solubility changes. Low amounts of cellulose suggest conservation treatments designed for lignin.

Chemically altered lignin has increased solubility. The use of dehydrating agents, alkaline solutions or hypochlorite bleach may solubilize structural lignin. Prolonged treatment with PEG may result in depolymerized PEG whch may solubilize lignin. Conservation treatments based on cellulose are not adequate for wood with high relative amounts of lignin.

The presence of extractives and inorganic components such as calcium carbonate, calcium sulphate, silica and sodium silicate, iron and sodium chloride have specific conservation implications.

Deteriorated waterlogged wood has changed physical characteristics, e.g. specific gravity, moisture-holding capacity, shrinkage and strength.

Morphological changes caused by chemicals, bacteria and fungi may destroy the integrity of the tissue or cells and cause increase or decrease in permeability and cause wood chemical changes, all of which have conservation implications.

I. INTRODUCTION

The need for the analysis of archaeological waterlogged wood prior to research on conservation processes or application of conservation treatments is widely recognized (Christensen, 1972; Hoyle, 1976; Florian, 1977(b), 1978; McCawley, 1977; Jesperson, 1979; Barbour, 1980; Grattan et al, 1980).

The need for standardizing the analytical methods as a necessary scientific approach to conservation research on this material has been expressed by Hoyle (1976) and Hoffman (1980). Despite this recognition of the need for a scientific approach and analyses, there is a dearth of analyses in the literature. Of the analyses reported only a few have been interpreted in terms of their conservation implications (Christensen, 1972; Barkman, 1975; Blackshaw, 1976; Florian, 1977 a & b, 1978, 1981 a & b; Barbour, 1980).

This dearth of analyses may be in part due to the general feeling that it is difficult to design a simple analytical approach to such a variable material (Rosenqvist, 1975; Grattan et al, 1980). Also it may be due to the fact that the conservation implications of the analyses are not well understood.

This paper presents a selected review of analyses on waterlogged wood from mainly terrestrial wet-sites and an interpretation of the conservation implications of these analyses. In many cases the implications are speculative but the main purpose of this review is to bring about an awareness of the significance of the analyses.

The variability of waterlogged wood and its responses on drying makes a simple routine analysis look difficult. But the task looks less difficult when the reasons for the variability are understood.

Basically the variability is due to the sum total of the: different states of deterioration; different wood species' inherent characteristics; different physical description of the artifact; and different history of the artifact prior to burial.

Due to limitations in space this paper will primarily deal with "different states of deterioration". General statements about the other three aspects will be presented.

II. DIFFERENT STATES OF DETERIORATION

The variability of the state of deterioration is due to the results of <u>different burial environmental conditions</u> (Greaves & Levy, 1968; Kohara & Okamato, 1956; Kohava, 1956; Kaarik, 1974), <u>length of time of burial</u> (Sen & Basak, 1955; Sen, 1956; Varossieau, 1950; Varossieau & Breger, 1952; Van Krevelen, 1952; Wayman et al, 1971) and <u>different agents of decay</u>

(Barghoorn, 1949; Sen & Basak, 1957; Fairbridge, 1967; Greaves, 1971 and Kaarik, 1974). The end result is wood which has been altered chemically, physically and morphologically.

1. Chemical Changes

It is important to keep in mind that decomposition of wood starts in the outer layers and proceeds inward (centripetally) with increase of burial time (Sens & Basak, 1957; Barkman, 1975; Christensen, 1978). Because of this, gross chemical analysis of partially changed wood may be meaningless. A review of the chemical changes found in ancient wood is presented by Sens & Basak (1957). Progressively, the cellulose and hemicellulose content decreases, the inorganic ash content increases and the lignin amount remains relatively constant. Variable changes in extractives (tannins, resins, pigments, etc.) may also occur. The changes proceed centripetally.

(a) Cellulose and Hemicellulose: Cellulose and hemicellulose are rapidly destroyed in waterlogged wood under a wide range of environmental parameters. Residual cellulose has been measured by Kohara and Okamoto (1956) and Kohara (1956) in an attempt to calculate a half life for cellulose in softwoods and hardwoods in ancient architecture and excavated waterlogged wood. For these buried woods the extrapolated half life for softwood is 2000 years and for the hardwood 200 years. These figures unfortunately do not have general application because of the variables for each wood as mentioned previously. Also exceptions are the rule, Wayman et al (1971) reported that 55% of the original cellulose remained in a 10-million-year-old piece of white pine. Infrared spectra analysis of this residual cellulose showed loss of crystalline structure.

Hahn and Harlow (1942) showed by X-ray diffraction patterns that the cellulose remaining in 2000-year-old buried stakes and wattles of the Bolyston Street weir was also non-crystalline cellulose and is probably oxycellulose. This residual cellulose when dissolved in cuprammonium hydroxide showed a marked decrease in viscosity and when treated with 70% sulfuric acid did not swell. These physical changes indicate extensive chemical modification. Thus the cellulose as described above may be reduced in amount or absent and altered chemically and structurally.

The Conservation Implication

i) Change in Adsorbency - Rosenqvist (1975) states that the moisture adsorption of wood is considered to be directly proportional to the amount of non-crystalline or amorphous cellulose present. (In response to this statement, Biek (Rosenqvist, 1975) considers voids and type of wood to be also important).

The increase in adsorbency is a result of the loss of cellulose and hemicellulose from cell walls leaving submicroscopic capillaries which increase the adsorptive surface area.

ii) Hysteresis - Waterlogged wood with decreased amounts of cellulose if allowed to dry and shrink cannot return to its swollen state. This hysteresis effect is attributed to the bonding of pairs of depolymerized cellulose groups which are drawn together on drying and are unavailable for later water adsorption (Rosenqvist, 1975).

iii) Cell Wall Shrinkage - Freeze-drying wood with chemically altered cellulose results in water sublimation from voids preventing collapse but cell wall shrinkage occurs due to the bonding of pairs of depolymerized cellulose as described above (Rosenqvist, 1975).

iv) Solubility Change of Cellulose - Prolonged pretreatment (e.g. acid treatments) hypothetically could hydrolyse altered cellulose.

v) Conservation treatments should be based on residual amorphous cellulose. It is obvious that wood preservation or dimensional stabilizing treatments used in conservation based on normal crystalline alphacellulose may not be effective with residual amorphous oxycellulose.

vi) Reduced Amounts of Cellulose - Loss of cellulose leaves relatively more lignin. It is this lignin which has to be considered in conservation treatments if this is the case.

(b) Lignin: Lignin unlike cellulose is extremely persistent. It is the precursor of coal and oil (Breger, 1952). This persistence is shown by its presence in preglacial 800,000-year-old wood (Varossieau & Breger, 1952; Gortner, 1929) and 100-million-year-old wood (Wayman et al, 1971). These woods have no native cellulose but near normal lignin amounts.

This lignin, like the residual cellulose, also may be chemically modified. Varossieau & Breger (1952) showed that at the surface of 450-year-old waterlogged piles the lignin showed an increase in methoxyl content while normal levels were observed internally.

Wood deteriorated by Brown Rot fungi can leave the wood as a virtual skeleton of altered lignin which is characterized by a decrease in methoxyl content (Kirk, 1971).

Conservation Implications

i) Increased Relative Amounts of Lignin over Cellulose - The conservation treatments must consider the chemistry of lignin as previously stated.

ii) Solubility of Lignin - Native lignin is soluble in commonly

used dehydrating solutions. One of the common methods for the isolation of native lignin involves the use of alcohols such as methanol, butanol, or benzyl alcohol in the presence of small amounts of anhydrous hydrogen chloride. Prolonged extraction with ethanol at room temperature dissolves 8-10% of the lignin in spruce wood (Casey, 1966. p. 53).

Lignin is soluble in ethylene glycol. Hibbert & Marion (1930) describe the extraction of a lignin derivative (glycol-lignin) with ethylene glycol in the presence of 0.05% HCl or trace amounts of iodine or dry hydrogen chloride. Blackshaw (1976) showed after long term treatments with polyethylene glycol (PEG) that the PEG did depolymerize. It is conceivable that ethylene glycol could form during PEG treatment and in the presence of small amounts of HCl left after pretreatment extensive lignin extraction could occur.

Lignin is soluble in alkaline solutions. Woods are naturally acidic (Gray, 1958) and show remarkable resistance to strong acids. Wangaard (1966) reports that wood is particularly resistant to organic acids and to low concentrations of strong mineral acids but that hemicellulose and lignin are susceptible to alkaline solutions. Native lignin is extrated in 4% sodium hydroxide. The 1% alkali solubility test for decay is based on the fact that Brown Rot fungi alter the lignin to increase its alkaline solubility (Casey, 1966, p. 90) where as Soft Rot fungi do not cause an increase in alkaline solubility of lignin.

Lignin is soluble in hypochlorite bleach. "Lignin is subject to both oxidation and chlorination. Either of these reactions can occur with hypochlorite bleaching depending on the pH (Casey 1966, p. 482)". If the surface of waterlogged wood was weathered the lignin may be partially solubilized and easily removed by bleaching leaving an abnormally white surface.

Final statement - The conservation implications of lignin solubilities suggest that dehydrating solutions, depolymerized PEG, alkaline solutions and hypochlorite have the potential to dissolve altered lignin, often the only structural component left in waterlogged wood.

(c) Extractives: Extractives such as resin, wax and oil, which normally impregnate cell walls or are deposited on cell wall surfaces or in the lumen of cells, undergo different degrees of chemical and physical changes (Sen, 1956; Sen & Basak, 1957; Barghoorn & Spackman, 1950; Mitchell & Ritter, 1934). Some are extremely persistent. Extractives which give the characteristic colour to wood are still present in lignite (Mitchell & Ritter, 1934). Wayman et al (1971) reported resin still present in a redwood sample 100 million years old.

The extractives are generally considered to be those materials soluble in neutral solvents such as ether, alcohol-benzene and water.

Smith & Kurth (1953) give a sequence of extractions for cedar phloem as follows: hexane - oils, fats, waxes, resins; benzene - fats and resins not removed by hexane; methyl ether - flavons (coloured material); hot water - tannin and soluble carbohydrates; ethanol - phlobaphenes (coloured material).

Conservation Implications

i) Removal of extractives make the wood more permeable.

ii) Dehydration solutions may remove extractives and cause colour change.

(d) Inorganic component: Generally speaking, archaeological waterlogged wood can be considered as belonging some place in the long and complex process of coalification or fossilization of wood or in the process of humus formation. If destined to be coal the H/C and O/C ratios of wood show a continual increase in carbon (Van Krevelen, 1952), whereas fossilization is expressed by an increase in the inorganic components from the environment and a decrease in carbon content.

The ash content of normal wood generally ranges from 0.2 to 1.0%. Calcium, potassium and magnesium usually make up the bulk of the metal elements. Large amounts of chloride ion may be present in wood associated with marine sites. Silica is also usually present (Casey, 1966, p. 89).

Increases in the inorganic components in archaeological waterlogged wood have been reported (Christensen, 1972; Barkman, 1975; Blackshaw, 1976). The inorganics present will depend on the Eh/pH and composition of the burial environment. Impregnation and precipitation in organic material of calcium carbonate, calcium sulfate, silica or sodium silicates, iron oxide or iron sulfide) sodium chloride may occur (Rolfe & Brett, 1969).

Conservation Implications

i) Calcium carbonate - Acid pretreatments will cause carbon dioxide formation which may cause felting of surface friable cells.

ii) Calcium sulfate (gypsum) - surface deterioration by calcium sulfate is reported by Florian, 1980. The damage is due to crystal formation and lignin removal. Gypsum is used in the sulfate pulping process to remove lignin (Casey 1966, p. 237).

iii) Silica or sodium silicates - In undegraded wood cell walls silica may be deposited in the intercapillary spaces whereas in partially degraded lignified cell walls it is deposited in the framework originally occupied by cellulose (Rolfe & Brett, 1969; Sieve et al, 1959).

Silica is highly soluble at pH 11. Any conservation treatment at this pH may remove silica which is already doing an excellent job by bulking potentially collapsable cells. Bulking treatments may not be necessary or ineffectual in highly silicatized wood.

iv) Iron - Iron oxide corrosion products on wood may cause autooxidation of cellulose or hydrolyses due to electrolytic products leaving beneath it only residual lignin (Pinion, 1970; Farber, 1954; Marian & Wissing, 1960).

Removal of the corrosion products may expose residual lignin which cannot support itself (Florian et al 1978). In extreme cases the wood structure may be completely replaced by the corrosion products (Keepax, 1975).

Soaking woods associated with iron in metal containers or with other objects associated with metal or in salt solutions or solutions containing biocides with metallic ions may encourage unodic cathodic microenvironments and resultant electrolytic degradation of wood.

Iron sulfide is deposited in wood by sulfate reducing bacteria. Its presence in terms of conservation implication has not been investigated. The dissolution of the salt would release iron ions which could be involved in dissolution of cellulose as described above or the release of sulfide ions could hypothetically be involved in lignin dissolution (Casey, 1966, p. 237).

v) Sodium Chloride - Wood with high content of sodium chloride (salt) may have a friable surface due to salt crystal degradation (Highley et al, 1971).

Salt can act as an electroyltic bridge for anodic cathodic corrosion of wood in the presence of iron.

2. Physical Changes

(a) Specific Gravity: Increase in specific gravity may be due to actual increase in inorganic materials or compaction of tissue (Wayman, et al, 1971; Sen & Basak, 1957) as a precursor to fossilization.

Decrease in specific gravity suggests loss of organic materials.

(b) Moisture holding capacity: A reduction in moisture holding capacity (Sen & Basak, 1957) may occur due to compaction and impregnation of inorganics. An increase occurs with loss of cellulose (Rosenqvist, 1975).

(c) Shrinkage: The excessive shrinkage of deteriorated waterlogged wood on drying was reported as early as 1942 by Bailey & Barghoorn. In the history of conservation of waterlogged wood artifacts, shrinkage values have been consistently

reported because it is this dramatic excessive shrinkage which has to be prevented so as to preserve the near normal size and shape of the artifact.

The excessive shrinkage of an artifact may be due to cellulose loss, inherent characteristics of the wood species, or physical features such as size and cut in relation to the grain of the wood.

(d) Strength changes: In small artifacts the strength changes are not as important as structural wood members of a building or boat. The chemical changes may cause deterioration of all aspects of wood strength.

Brittleness is a common characteristic of wood which has lost the major cellulose component. Such lignin rich wood has low abrasive resistance and is prone to brash breaks.

3. Micromorphological Changes

(a) Chemical Deterioration: The micromorphological changes in wood tissue is characteristic for the specific cause of deterioration such as chemical, physical or biodeterioration. There is little data in the literature which relates directly to the micromorphological changes to the chemical aspects of the burial environment.

i) Hydrogen Sulfide - There is reference to the speculative deterioration role of hydrogen sulfide. Barghoorn (1949) postulates that the prolonged presence of small concentrations of this gas and its aqueous solution (sulfuric acid) may bring about the chemical hydrolysis of cellulose. Woody samples examined by him excavated from one site at different age stratas of clay, peat and silt showed virtually identical degradation changes. Hydrogen sulfide was present in all these strata. Microbiology analysis showed complete absence of sulfate reducing bacteria. The primary wall and amorphous middle lamella retained their original form in the tissue of the stakes. The secondary walls of tracheids, fibers, vessels and rays showed various stages of disintegration in to a final granular residue with little if any birefringence.

Barghoorn (1949) observed a sequential pattern of deterioration in these secondary walls which reflects the three (S_1, S_2, S_3) layered structure of these walls. The sequence is first S_2, S_3 and finally S_1. The differences in rates of deterioration of these layers is due to their different chemical composition and molecular organization. The most resistant is the first formed S_1 layer. It has the highest concentration of lignin which is mainly responsible for the resistance. In the woods examined by Barghoorn (1949) this thin layer still retained some birefringence. The least resistant layer is the middle (S_2) layer which has the lowest lignin concentration and makes up at least 75% of the total volume of the secondary wall.

Barghoorn (1949) reports that under the anaerobic conditions of deterioration involving hydrogen sulfide less hydrolysis of the cellulose occurs in heavily cutinzied, suberized and lignified walls or wall layers and in walls that contain a relatively high ratio of terpenes, resins or other so-called encrusting substances. Sen & Basak (1955) reported similar microscopic deterioration in buried building foundation 200-600 years old of Pinus sylvestris which they postulated had undergone non-biological deterioration. Wayman et al (1971) using the scanning electron microscope recorded the micromorphological changes of 10 million year old white pine wood which they speculate had undergone deterioration by oxidation, heat or possibly bacteria. It differs from the deterioration reported by Barghoorn (1949) and Sen & Basak (1955) in that the S_1 and S_2 layer are intact but there is an absence of microfibrillar structure of the S_3 layer. Loss of pit membranes, with only torus residues remaining, and the occurrence of numerous spiral checks in the tracheid wall were also observed.

ii) Bicarbonates and Carbonic Acid - Sen & Basak (1975) reviews other chemical theories of decay and report that the role of bicarbonates or carbonic acid in deterioration of submerged wood is not conclusive.

iii) Metals - Metal associated with buried wood can cause local acid anodic and alkaline cathodic microenvironments in the wood. (Pinion, 1970; Farber, 1954; Marian & Wissing, 1960). Acid and alkaline deterioration of the wood may occur at these poles. Also the corrosion products of iron may catalyse auto-oxidation of cellulose (Marian & Wissing, 1960). In extreme cases the wood structure may be completely replaced by the corrosion products (Keepax, 1975).

Tannin imparts natural resistance to woods against biodeterioration. Krause (1954) showed that the reaction of tannin and iron producing an iron stain (iron tannate) in tannin rich hardwoods removed much of this natural decay resistance. The iron tannate form a blue grey stain in woods.

Iron corrosion products may form a continuous margin on the surface of wood beneath which the cellulose in the cells has been removed and only a lignin skeleton remains.

Iron crystals may accumulate in the pit chamber or pit membrane in pits of cells (Florian et al, 1978) and decrease permeability.

Iron salts may precipitate in the early wood tracheids of softwoods and cause ring shakes (Florian et al, 1978; Faber, 1954).

(b) Physical Deterioration: Physical aspects of the environment may also cause deterioration prior to or during burial. Cyclic freezing has been reported (Erickson & Chen, 1974) to

significantly decrease unaspirated pits in sapwood and only slightly in heartwood. This would enhance deterioration by making the wood more permeable.

i) Bacterial Deterioration - As early as 1929, Waksman & Stevens (1929) stated, "chemists are willing to agree that the disintegration of wood is largely a result of the activities of bacteria and fungi". Van Krevelen (1952) postulates that bacteria have contributed to the early stages of the coalification process.

The role of bacteria in the deterioration of wood is often overlooked even though it is extensively documented in the literature. Similar micromorphological changes in wood have been reported to be caused by bacteria in quite different environments such as: ground contact or buried (Boutelje & Bravery, 1968; Levy, 1974, 1975); water cooling towers (Greaves & Levy, 1968; Krause, 1954); mines (Greaves, 1969); ponded logs (Ellwood & Ecklund, 1959; Knuth & McCoy, 1962; Levy, 1974; Bolton & Petty, 1975). In all cases the wood is nearly water saturated. Leise & Greaves (1975) in their excellent review article describe the bacterial decay pattern in softwood and hardwood. Usually the first change in both woods is the depletion of cell contents of wood ray parenchyma cells which is followed by the degradation of the pectin rich cross field pit membrane. As decay continues the cell walls first show loss of birefringence and finally may completely disintegrate (Liese, 1970).

Softwood tracheids and hardwood fibers and vessels show similar decay patterns. Electronmicrographs of softwood tracheids (Greaves & Foster, 1970) show both shallow and deep erosion troughs on the S_3 lamella of softwood tracheids caused by bacterial enzymatic digestion. Depending on the degree of decay the erosion troughs may not only remove if present the textured or warty surface of the S_3 layer but may penetrate through the S_2 and S_1 layers of the cell wall leaving only a skeleton of primary wall and middle lamellae (Greaves, 1969). The bacterial troughs are also visible with light microscopy and can be distinguished from soft rot decay patterns by the fact that they occur on the inner surface of the cell wall and not inside the S_2 layer of the cell wall as with soft rot. Greaves (1969) has observed in a few rare cases, degradation caused by bacteria of the primary wall and middle lamella leaving the tissue as separated tracheids.

The bordered pits of softwood tracheids show three patterns of bacterial decay. These were first illustrated and described using light microscopy by Greaves (1969) and were supported with electron-microscopy by Greaves & Foster (1970). The reasons for the three patterns is not known. They may represent specific bacterial species which attack selectively one of three parts of the bordered pits: 1) cellulose-lignin walls of pit cavity; 2) cellulose-rich margo strands; or 3) pectin-rich torus. Degradation of the pit cavity causes enlarge-

ment of the pit aperture and degradation of the margo or torus causes loss of the pit membrane.

In most cases it is the sapwood which is affected but heartwood under long term deterioration such as archaeological material (Greaves & Levy, 1968) may also show changes similar to bacterial decay patterns. In heartwood, the lignification of the torus and increase in polyphenolic extractives apparently prevents bacterial attack but under long term burial they may be leached out.

Softwood attacked by bacteria shows a striking increase in permeability (Knuth & McCoy, 1962; Dunleavy & McQuire, 1970; Ellwood & Ecklund, 1959; Unligil, 1971; Bolton & Petty, 1975). Bolton & Petty (1975) measured the resistance to longitudinal liquid flow in unponded wood and ponded wood, they attributed a striking 60% reduction in resistance to be due to removal of pit membranes in ponded logs. Greaves & Foster (1970) state that the increase in longitudinal and tangential permeability is due to: 1) removal of hydrophobic dense tertiary layer; 2) fine canals and tunnelling through cell walls which increase the flow of liquids in the wood tracheids; 3) enlarging of aperture of bordered pits and, 4) removal of membrane of bordered pits. They state that the increase in radial permeability is due to removal of simple pits of crossfields and loss of contents of ray parenchyma cells.

Strength losses occur in bacterially-decayed wood, the degree of loss depends on the environment and length of time of exposure. Leise and Greaves (1975) showed no loss of strength in softwood logs ponded up to one year but a 10-15% loss occurred in 3 years. Boutelje & Bravery (1968) observed bacteria only in the sapwood of 75-year-old buried spruce and pine piles but recorded a loss of strength in both sap and heartwood. The surface macroscopic appearance of wood under bacterial attack may appear relatively normal. Some surface softening when wet may be apparent and on drying, cuboidal checking usually does not occur, but shrinkage and warping may occur. In the above 75-year-old buried piles the soft area extended only 3-5 cm in depth.

ii) Fungi Deterioration - Fungi deterioration of wood is very common. It may occur while the tree is alive, fallen on the forest floor, stored or in an artifact while in use or when discarded. Fungi present in an artifact may not be active and could have originated in any one of these environments. The fungi-like bacteria show successions (King & Oxley, 1975) in wood. The wood-decay fungi fall into four groups: surface mould; sap stain; decay; and Soft Rot fungi (Butcher, 1974). Surface moulds and sap stain fungi utilize the carbohydrates in wood rays, they do not destroy the lignin or cellulose.

Some decay fungi species can digest only cellulose and some

species only lignin. These decay fungi produce bore holes through the cell walls, lie in the lumen of the cell and digest the cell wall from lumen inwards (Wilcox, 1964, 1968; Butcher, 1975). Dry Rot of wood is caused by decay fungi.

Brown Rot is due to decay fungi which selectively digest cellulose. The structural appearance of the cells is maintained throughout the decay process because the lignin matrix remains but it is altered chemically in that it has an increase in alkaline solubility and increase in methoxyl content. The wood may have weight losses up to 50% and comparable shrinkage percents. The shrinkage causes fracturing of decayed wood from normal wood and shrinkages, splits and cuboidal surface cracks. The dried Brown Rot decayed wood has low specific gravity and decreased wetability and low moisture content (Wilcox, 1968; Leise, 1970).

White Rot is due to decay fungi which selectively digest lignin. During the process of decay the thickness of the cell remains but a widening of interfibrillar spaces in the cell walls occurs. This leads to increase porosity and swelling capacity. The latewood deteriorates first. Eventually white residual fibrous cellulose remains with little strength and prone to collapse. Finally the cells are completely decomposed. White rot occurs in pockets thus often called Pecky rot (Wilcox, 1968; Leise, 1970).

Soft Rot occurs in wood with abnormally high water content such as water cooling towers, wood chips and buried timber. It is caused by a group of Ascomycetes and Fungi Imperfecti (Savory, 1954 a & b) which penetrate and lie in lytic troughs only in the S_2 layer of the cell wall. The lytic troughs are oriented with the angle of the cellulose microfibrils.

It is Soft Rot which is most commonly associated with the surface of archaeological waterlogged or buried wood (Bolten & Petty, 1975; Levy, 1968 & 1975). Savory (1954 a & b) described Soft Rot as superficial. The surface is soft and easily eroded. There is a rapid transition from decayed to sound wood. When Soft Rot decayed wood dries, a thin brown surface layer with surface cuboidal checks is observed immediately below this layer is sound wood.

Soft Rot shows preferential decay of late wood cells causing exfoliation of surface growth rings.

Coweley states that decayed wood differs from sound wood, for which the standard methods of wood analysis were designed, in resistance to fragmentation during grinding, in hygroscopicity and in solubility filtration and surface properties. Each of these factors can influence the results of chemical analyses and necessitates partial modification of the standard methods of wood analysis. Coweley, thus present "Methods for Chemical analysis of Decayed Wood".

Conservation Implications

The most important conservation implication of morphological change is that the integrity of a tissue must be maintained. Knowing the morphological changes such as pattern of cell wall decay, presence of corrosion products, aspirated pits, bacterial degradation or type of fungi decay allows one to predict the problems on drying, chemical reactions with chemicals that may be used for the drying process and permeability of the material.

III. FINAL STATEMENT

In many cases it may be impossible to do any analyses on the material of the artifact because of its preciousness. A great deal of information which will assist in predicting the waterlogged wood's response to drying can be obtained in the literature (Panshin & deZeeuw, 1970) on physical characteristics of the wood species such as variable shrinkage rates, moisture holding capacity and inherent weaknesses and permeability (Florian, 1981 a & b).

Analysis of the cut of the wood in reference to the grain and the size and thickness of the piece can also assist in predicting drying problems. Observing anomalous growth such as tension and compression wood, mixed tissues such as bark, sapwood, heartwood and pith and plant parts such as knots, branches and roots also will help in predicting drying problems (Florian, 1981 a & b).

Also knowing the history of the artifact prior to burial such as method of fabrication or usage will also help to predict problems on drying.

There are no conclusions to this paper. The purpose of the paper is to outline the variations in waterlogged wood and suggest the conservation implications of the changes in the wood with specific reference to deterioration. Comments, additions and omissions are welcomed.

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REFERENCE MATERIALS

Coordinator : J. Winter (USA)

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Programme 1978-1981

1. Standardization methods in radiography: survey and development of standard radiographic devices for use in the museum field (Ashley-Smith, Bosshard, Stone).
2. Survey and inventory of collections of radiographs and infrared photographs (Van Schoute).
3. Methods and standards for the replication of X-radiographs (Baer, White).
4. Guide to commercially available reference materials (Winter).
5. Reports on reference collections held by various museum laboratories (Feller, Mosk, Winter).

TEXTILES

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Programme 1978-1981

1. General problems in conservation and restoration of textiles (Finch, Flury-Lemberg, Mantilla de los Rios).
2. The analysis of dyestuffs in ancient textiles (Whiting, Masschelein-Kleiner, Hofenk-de Graaff).
3. The influence of washing agents on the deterioration of ancient textiles (Tucker, Hofenk-de Graaff).
4. Technical studies on weaving in early chinese silks (Riboud).
5. The study of the influences of silk weighting on the deterioration (Hofenk-de Graaff).

General aim of the whole working group: Promotion of contacts between the various groups concerning the conservation of textiles.

PROBLEMS IN THE CONSERVATION OF TEXTILES: NEEDLE VERSUS ADHESIVE

Hanna Jedrzejewska

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Textiles

PROBLEMS IN THE CONSERVATION OF TEXTILES: NEEDLE VERSUS ADHESIVE

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ABSTRACT : a systematic review is given of problems connected with preferences and objections concerning the choice of sewing or glueing procedures in the treatment of old textiles.The conclusion is that either system may be "gentle" or "drastic" depending on circumstances.Decisions in favour of one or the other technique should be free of personal prejuditions and based more on the actual needs of the object.In many cases the most effective seems a clever combination of both procedures.

x

x x

"To sew or to glue" is a kind of eternal controversy between restorers of textiles,with enthusiastic supporters of one technique and equal disaprovement of the other one.But this seems to be based more on subjective feelings and habitudes than on real arguments.

Generally,needle or adhesive are used mostly for different kinds of repairs and reinforcements.It is not intended to discuss in this paper the details of these particular operations ,but just to consider the possible contribution of needle or adhesive in carrying out the necessary treatment.

ARGUMENTS FOR AND AGAINST THE NEEDLE AND THE ADHESIVE

These will be some of the arguments as given by conservators of textiles:

- for the needle,

it is a "gentle" procedure,done with materials naturally similar to original yarns.It enables local repairs and a good control of almost every stitch.It is considered as reversible(threads can be removed),does not disagree with natural properties of the textile,as well mechanical as physical.Is well suited to imitate the

structure of the weave and can be made completely,or almost,unnoticeable. There only is mechanical contact with the textile.

- against the needle,

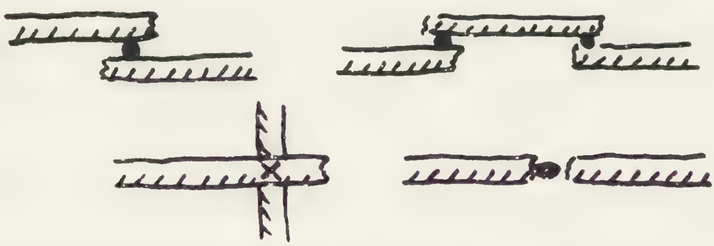
considerations have to be extended over the needle and t h r e a d .The usual operation consists of drawing the needle and thread t h r o u g h the textile. Even when the needle and thread are very fine,and the stitching is very delicately done (e.g.by inserting the needle inbetween the yarns of the repaired weave) irreversible holes are always produced.If the thread is not soft enough it may cut into the textile. It may also become too taut or too loose,especially after washing.In most cases stitches are visible and interfere with the aesthetic appearance. Thread used for repairs,when dyed,may bleed or fade,or deteriorate more quickly than the original.The alleged reversibility is dubious in many cases.

The sewing technique is not always effective,e.g.for ragged edges,loosely hanging or unravelling threads etc. The procedure takes a very long time and needs hands of long practice.

- for the adhesive,

there are cases when only the use of adhesive can save the textile from further damage or disintegration,and where the use of needle is not conceivable (e.g.silk flags, canvas paintings,etc.),

Final good or bad effects depend on the kind of adhesive,its amount and method of application.If properly applied it may be completely invisible ,saves lots of time and can be applied in cases when needle is rather ineffective. It may be applied to the whole object or only locally,and work by surface contact or by deep infiltration into fibers and weave. In common repairs it may be successfully used for local repairs of tears,ragged edges,slipping yarns etc./il.1/.



Il.1. Local repairs by spot-glueing.

Minute droplets of adhesive are put i n b e t w e e n yarns to join broken threads or fix the slipping ones. Invisible.Applicable to thicker yarns /1/.

- against the adhesive ,
here the arguments are the heaviest.The first argument is that,generally, the method is a very "brutal" one ,irreversibly disfiguring the textile and based on a material very foreign to materials in the object.The adhesive is supposed to age more quickly,lead to discolourations and stains,cause stiffness,and also change the natural properties of the textile (flexibility,texture,feeling,colours, etc.).It may attract dust and be chemically active towards yarns and dyes.

In dependence how the adhesive was used,on the whole object or only locally,the disfiguring effects will also be different.With the exception of the already mentioned "spot-glueing" there is no good local control of effects.

The opposition against the use of adhesives is far from rational.Some people wouldn't apply this technique in any way.Others just feel a lack of necessary experience and try to be careful for the sake of the object.But there certainly is a lack of a critical systematic review as concerns the possible applications of adhesives in certain cases when the needle is not satisfactory.There also is a basic question : is it ethical to use adhesives for the treatment of textiles?

ETHICAL PROBLEMS

A discussion on proper and wrong ways in the treatment of textiles has to be started with considerations on the aims of conservation in general.

Old objects,notwithstanding their type,age,value,function,etc. all have to be treated as d o c u m e n t s of the past human activity. And a document preserves its documentary qualities just so long as it stays authentic. Hence,the original features come as first in considering treatments of conservation.And the moral (ethical) duty of the conservator is to preserve as much of this evidence as only possible.

But in old objects this evidence may be only fragmentarily preserved. And the conservator's task is not only to save the relic from further disintegration but also to make it as presentable as possible.Quite often it is not an easy task and decisions have to be made what should be preserved and what will have to be destroyed.These decisions usually are difficult and often disputable.

The main ethical principle here is to apply such operations that will enable to preserve as much original evidence as possible .The conservator must give his main attention to this problem.He must have a deep respect for the authentic substance and try to preserve it with the least of interference .

In textiles there is a large diversity of factors of documentary value /2/, connected as well with the materials

themselves as with their secondary use for the production of other goods. In the presently considered case of needle versus adhesive the most directly open to change may be the optical and mechanical features (colour,brightness, transparency,softness,pliability,sheen,texture,etc.).Also certain aesthetic qualities could be influenced by techniques and materials used for repairs and protection.

Thus,the problem "needle versus adhesive" has to be confronted not only with technical but also with ethical requirements. And the ethical requirements should come first and be decisive as concerns the choice of methods and materials.

REVERSIBILITY

In its theoretical intention this is a very reasonable ethical and technical requirement stipulating that anything added to the object during treatment should be removable,now and in the future,"without any harm to the original". This should be maintained as far as possible but quite often the alleged reversibility does not exist at all even that apparently all necessary requirements have been kept.

Generally,reversibility has more chance with mechanical kinds of operations than with chemical treatment. In textiles it is of course the same.But even the removal of darning or stitching,usually considered as "fully reversible", will leave irreversible holes when removed and the condition of the object will be changed for the worse.And who will dare to pull out the inwoven yarns introduced to fill a hole ?

When chemical products are used (e.g.adhesives) , and even the well soluble ones, there never will be a complete removal of them even with the most suitable solvent.In spot-glueing there is even no suggestion for reversibility. The removal of glue,on immersion in liquid during dissolving operation,will cause,first,the slipping away of all fixed yarns.And the glue will stay where it was applied. The same will happen with the removal of adhesive used for the consolidation of fibers. The fibers will float away,the adhesive will stay.

The only reasonable solution here is to use the adhesive as sparingly as possible ,and eventually to use the step-wise kind of treatment /1/.That means dividing the planned procedure into several particular steps and for each step using a different kind of adhesive not influencing the former one.The effects cumulate to the final end.The removal of materials used , especially the later ones,can be done without having the textile again in its precarious condition.

The opposite to this "pseudo-reversible" operation is when the same adhesive is used for all steps, e.g.for the consolidation of yarns and for fixing a ba-

cking.In this case the operation is practically irreversible even when a very easily soluble adhesive is used , because the solvent will loosen everything that the glue is supposed to keep together.

So,as concerns the principle of reversibility in general it is not always possible to satisfy it in practice.There are many cases where the apparent reversibility is in fact nonexistent and cases where reversibility of treatment can not be realized for technical reasons. But the relevant ethical principle will be to keep as closely as possible to conditions of reversibility.

EXAMPLES

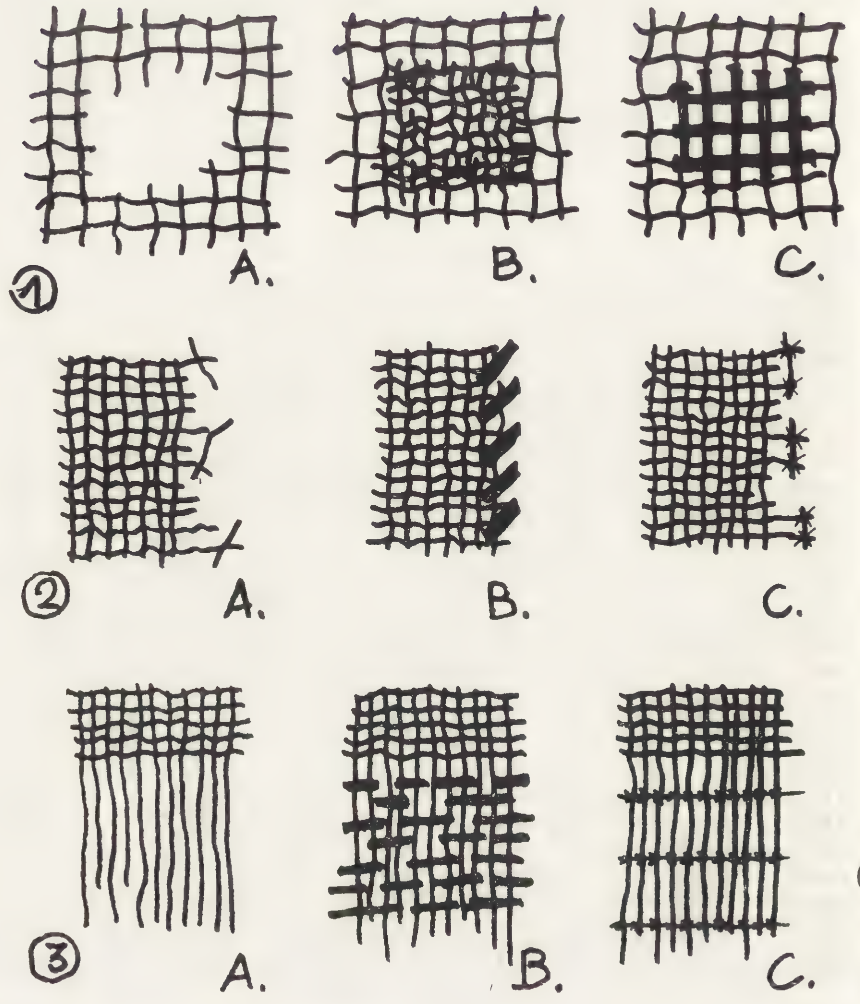
In conservation it is the object that is dictating its needs.And the task of the conservator is to satisfy these needs in the best possible way.The final result of treatment will depend not only on a particular method, but also on the kinds of used materials and on the way in which they are applied.

In problems of repair and consolidation at disposal are as well needles as adhesives. But there are different possibilities for the use of needle and different possible applications of adhesive. There also are different kinds of damages to be treated.Some basic points of this are diagrammatically presented on il.2. Considered are holes,ragged edges and loosely hanging yarns:

- holes. A hole may be filled in by darning (N=needle). The result will depend on the fineness of the needle and thread,on the thinnes of the repaired textile and on the delicacy of the hand of the conservator. May be visible,or lost to the eye when "artificial"(hidden) darning is done. As concerns reversibility,it is possible in theory,but in practice irreversible holes are left in the textiles after the pulling out of darning threads. A hole may also be filled by spot glueing of fragments of thread just to join the broken ends of yarns.If well done this is hardly visible at all,and may be considered as a very "gentle" way of repair. It even may be applied to lace.The problem is with eventual future washing.The adhesive has to be of the kind that will withstand immersion in water or solvent.

For the repair of larger holes patches may be applied.Here,either N. or A.(=adhesive) may be used,depending on the kind of textile and other technical possibilities.There also comes the factor of time.

Inweaving,commonly applied e.g.for the repair of tapestries is a specific kind of repairing holes.Theoretically,it is reversible,but the inwoven places are rarely outlined at the reverse with a colour thread as information for future restorers.So,it may even be difficult to find them.As a rule,holes are not repaired in



Il.2. Common kinds of repair.

A = kind of damage: (1) hole,(2) ragged edge, (3) loosely hanging yarns,
B = repair with needle: (1) darning,(2) overcasting, (3) couching,
C = repair with spot-glueing: (1) filling a hole with inserted threads,(2) fixing slipping yarns,(3) fixing loosely hanging yarns with a few threads spot-glued at the reverse.

archaeological relics.But their edges can be protected with a thread spot-glued at the reverse around the hole.

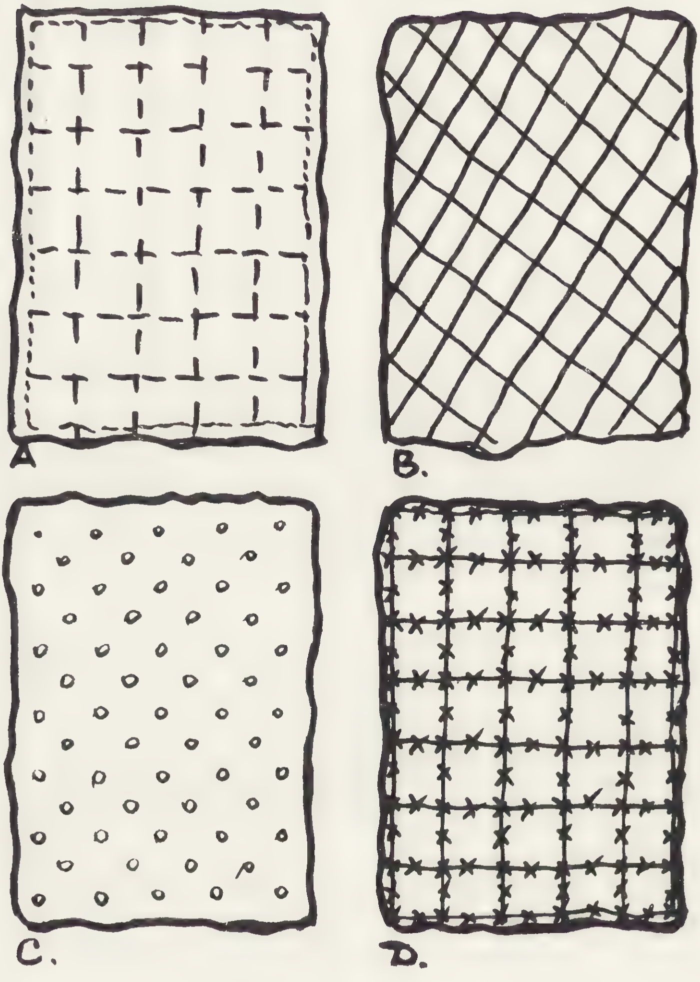
- ragged edges. Here are two possible cases: unravelling yarns or small yarn fragments just in danger of slipping away. In both cases as well N. as A. can be used with positive effect.The edges may be overcast ,with eventual backing of new textile,or yarns may be fixed by spot-glueing (A.).Quite obviously spot-glueing is much more "gentle" because it is not visible at all and helps to keep yarns in order and safely in place without distortion of weave and without disturbing optical effects. Ragged edges can also be protected by spot-glueing a thread,at the reverse,just at the edge that is in danger. Here it seems that (A.) is superior to (N.) as it is both more effective and less damaging.And reversibility is not required in the case of minute spots of adhesive hidden inbetween yarns.

- loosely hanging yarns. These may be fixed by needle with the help of couching to a lining,or may be very effectively held in place by a few threads spot-glued at the reverse. After this the yarns may be attached with a few invisible stitches to the eventual lining.It saves much time and is "reversible" in a way,because it can be unstitched from the lining without any harm to loose yarns,whereas with the needle technique of couching,the removal of threads will cause the yarns to be loose again.

However, against all principles of ethics is the not rarely applied solution of trimming away the loosely hanging elements in order to "free" the textile from all"messy"parts.

Problems of a protective backing,regularly applied as reinforcement for old textiles,are diagrammatically presented on il.3.Considered are different possibilities of fastening the backing to the textile.

The first possibility is to fix the new fabric by stitching (N.) across the old and the new one,in regular horizontal and vertical rows.The intention is that the lining will give support to the frail old object. The effects may not respond to this intention.First of all even the most delicately done stitching will not be without influence on the textile.Small holes,distortion of weave,sagging,etc.may result.With hanging tapestries it may happen that the tapestry will additionally to his own also have to bear the weight of the backing,instead to the contrary.Sometimes the lining is only stitched around the edges.This is a good protective cover but no mechanical reinforcement.In rare cases machine stitching is applied.This needs no further comments.Sometimes also tapestries and other hanging textiles are reinforced with



Il.3. Protective backing.

A = new textile backing fixed by stitching; B = new textile fixed with adhesive evenly spread on the entire surface; C = new textile fixed with adhesive laid in spots (according to V.Mehra) ; D = a lattice of supporting threads fixed by spot-glueing.No new textile. Reverse open for inspection(according to H.Jedrzejewska).

tapes or strips of fabric stitched at regular intervals on their backs.After some time this may show at the front as distortion of the weave.With the exception of the last method the reverse is totally and permanently covered and not open for inspection by specialists.It is also not open for inspection for the biologists.And the space between the old and new fabric is a perfect peaceful hiding place for insects and their young families.

A protective backing can also be fixed with the use of adhesive.In some cases no stitching can be applied at all,e.g. for crumbling silks,cottons,etc.In other cases the use of adhesive is technically more practical than sewing.There are different groups of adhesives and different ways of application.

The adhesive may cover the whole surface of the lined textile,or be put only in spots,or used just to fix a certain number of supporting threads. Adhesives may be applied dissolved in a solvent or in aqueous medium (starch paste),or even in solid state (heat-activated). (A) may stay on the surface of contact only or enter the old and new fabric deeper in.The reversibility of particular treatments is rather good as concerns the separation of object and lining.A complete removal of applied adhesive is of course out of question. And lining with the help of adhesives leads to a certain,more or less pronounced,stiffnes of the lined object,with the exception maybe of the spot-glueing technique.This also is the only operation that does not cover the reverse with no chance for inspection. And,generally,with the use of adhesives there is less chance,if any,of weave distortion.

FINAL COMMENTS

The following may be added to considerations about the competition between needle and adhesive :

1/ as concerns the use of (N.) in repairs there is one technique practically harmless to the object and that is when the fixing threads are not drawn through the weave but o v e r it,e.g. when fixing a fragmentary relic to a lining.Another way of sparing the original is to encase it between two layers of crepeline and do all the stitching on the outside of the original.

2/ in evaluating adhesives it has to be remembered that not only purely technical properties have to considered but also the tendency to catch dust by static electricity (also if the adhesive is only inside) and its resistance to attack by mould and bacteria.

3/ very important are considerations on the resistance to washing.There are objects (e.g.tapestries) that from time to time need cleaning and eventual washing in a liquid medium (water or organic solvents).And this may cau-

se serious problems,because the used materials may not be water or solvent resistant,or will resist any kind of cleaning,or the threads used for repairs may have a tendency to bleed,etc.These are factors that should be thoroughly considered before deciding on the method of treatment.

4/ in some cases also the time element may be of importance in the choice between (N.) and (A.),if they are both admissible,

5/ there is a safe principle in conservation of doing the "least necessary" (but doing it well!), so anyway not too much enthusiasm in stitching and the less glue the better, are making a good basic principle,

6/ a basic question that may be posed as concerns competition between (N.) and (A.) is whether the use of adhesives is at all admissible in the conservation of textiles - from the e t h i c a l point of view ? The answer from the author of this paper will be YES,of course when the treatment will be rationally done.But the question is left open for further discussion.

January 1981 Hanna Jedrzejewska, ICEC,
Stockholm-Warsaw.

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81/9/2

THE PRACTICE OF DRY-CLEANING IN THE UNITED KINGDOM

Sheila Landi

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Textiles

THE PRACTICE OF DRY-CLEANING IN THE UNITED KINGDOM

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Synopsis: A report of a meeting held at U.M.I.S.T. Manchester, in order to review the prevailing opinions held in the dry-cleaning industry of the doubts and requirements of museum conservators.

A review of the practice of dry-cleaning and the machines available for use in museum conservation departments in the United Kingdom, of the solvents available and the use of detergents. Mention is made of a trip made to Edinburgh in order to clean a number of costumes from the V & A collection, and the cleaning of a large embroidery in the open air at Osterley Textile Workshop.

Interest in dry-cleaning for museum textiles has increased greatly during the past few years. The scope of conservation, and along with that, the expectations of conservation techniques, has broadened and led conservators to look for solutions to problems, particularly of cleaning, in fields once regarded as out of bounds, or at least impracticable.

There are two institutions in the U.K. which own a machine for dry-cleaning museum objects - the Royal Scottish Museum, Edinburgh and the Victoria and Albert Museum, London. The first mentioned is an adapted commercial machine, and is available for use by conservators from other institutions in Scotland. It has a wide range of mechanical action available and can be used in the normal way for dry-cleaning clothes as well as with restricted movement for dealing with delicate objects. The solvent used is 1.1.2-trichloro 1.2.2.-trifluoroethane.

The second machine is a custom-built piece of apparatus on a much smaller scale which, while carrying out its function excellently when it is in working order, is so often out of use for one reason or another that it is difficult to assess its true value. The solvent used in this case is 1.1.1.-trichloroethane. There is extraction to the exterior of the building and a distillation unit but no facility for recovering solvent from the atmosphere. Modifications due to be made at the time of writing may well give a chance to report more fully by the time of the Conference. However, since it was not designed to deal with large or heavy objects, the V & A also makes use of an outside commercial dry-cleaner in whom we have learnt to trust, using perchloroethylene in a normal commercial machine. We also occasionally use white spirit.

The North West Area Service in Blackburn, Lancashire, England uses 1.1.1. trichloroethane in the open, without mechanical help, on a small but fairly regular basis.

Other textile conservators use commercial facilities or one of the solvents already mentioned as and when they find it necessary or practicable.

This was, and still is, the situation when Kathleen Moodie of the Royal Scottish Museum instigated a meeting between conservators, scientists, and commercial research and design personnel in an endeavour to find some answers to questions which arose from her first experiments in using their machine. Alongside these practical considerations were questions of a more fundamental nature arising from anxieties voiced by both technical and non-technical people about the long term effects on textile fibres of immersion in organic solvents.

The meeting eventually took place in March 1979 and was held under the auspices of The University of Manchester - Institute of Science and Technology Department of Polymer and Fibre Science. Those present

included four Scottish conservators who had all had some experience of the R.S.M. machine, myself representing the V & A machine, two research scientists from I.C.I. Solvents Division, a representative from the firm who made the Scottish machine, three conservation scientists, from the British Museum, the V & A Museum and the Textile Centre at Hampton Court, and a representative from the Fabric Care Research Association, Harrogate.

Instead of a formal agenda I had prepared a discussion paper which attempted to formulate the questions most often raised by those concerned with museum textiles, in a way which might elicit an evaluation of the factors involved in leaving the object dirty as opposed to cleaning it by means of an organic solvent.

Thus:- what would be the effects on the life expectation of the textile of leaving dirt, i.e. solid particles, soluble deposits and acidic concentrates, in the object as opposed to

1. the risk of the removal of natural oils such as lanolin from wool.
2. the leaving behind of trace elements from the solvents used, in the fibres.

or would the possible damage from 1 and 2 be justified by

3. the gain from improvement in appearance and handling?

This main question was to be discussed in relationship to the solvents in general use, the additives such as detergents which are used in commercial practice, and the mechanical action necessary to achieve the release of dirt.

It was also hoped to establish whether there was already any factual evidence, rather than emotional reactions, upon which to form a judgement of the effects of solvents and detergents. The effects of mechanical action are usually fairly visible!

It must be admitted that the professionals in the dry-cleaning world largely failed to understand that there was anything for the museum world to worry about. The question seemed meaningless to them. On the other hand, while there were plenty of opinions voiced, there was very little evidence, based on either actual research or observation, available. It had never been worthwhile to investigate the effects of solvents or detergents in such terms as we had set out. In addition no-one believed that it would be possible to set up any meaningful experiments which could produce the evidence required.

The museum world was, perhaps, not entirely convinced of this but accepted that very lengthy periods of work with highly sophisticated equipment would be required before solid evidence could be produced. The quantities involved and the changes, if any, made, were almost too small

to detect in themselves let alone to disentangle from all the other variables present. It did not seem that artificial ageing tests would be of much help in such a situation.

Meanwhile, those of us who were faced with the day-to-day problems of the conservation of objects required for exhibition or study were anxious to get as much information from the experts as possible. It was not so much a question of choice (since mostly we had no choice) but of getting the best out of the facilities we had.

The following is a precis of a report made from notes taken at the meeting by Anne Moncrieff reinforced with information taken from publications made by I.C.I. and the conclusions drawn from the actual work of museum conservators.

The discussion was directed under the headings

1. Solvents
2. Detergents
3. Mechanical Action
4. Damage & Research

but, in fact, these subjects overlap so much that they cannot really be separated.

Some general remarks on research have already been made. More particular points will emerge from the text.

In a paper published by I.C.I. in 1971[1] the ideal properties of a dry-cleaning solvent are listed as:

1. Must have good solvency power for grease but should not be too powerful a solvent.
   (It was admitted that these two were self-contradictory since high solvency power is required to remove solvent-soluble stains quickly and effectively but low solvency is safest, especially for dyes and the materials of accessories.)
2. Must be a pure chemical compound.
3. Must have low toxicity.
4. Must leave no residual odour.
5. Must be non-corrosive.
6. Must be easily recoverable.
   a. easily purified by distillation
   b. easily evaporated
   c. easily reclaimed during drying
7. Must be non-flammable.
8. Must have good stability under dry-cleaning conditions.
9. Must be cheap to use.

There follows a series of block diagrams comparing these qualities as found in a group of 6 solvents including perchloroethylene and the 3 others in which we are particularly interested. The results of these comparisons which are based on empirical information give the reasons why our choice has been made as it has.

Perchloroethylene, with a T.L.V. of 100 is too toxic for use outside an enclosed system, but for other reasons is out of the competition if an enclosed system is available, and need not be considered in great detail. It is, however, acceptable when used by a commercial dry-cleaner.

White Spirit (Stoddard Solvent) with a T.L V. of 500 has a high enough toxicity rating and a slow enough rate of evaporation to be used in the open although good ventilation or extraction is still necessary. It has died out as a solvent used in the trade since, being made from a number of fractions of hydrocarbons, it is not easy to distill and is highly flammable.

It has good solvency power without being too aggressive, and rarely upsets any dyes either natural or synthetic. Used in small quantities it is possible to filter out solid dirt and re-use at least once more

The rate of drying is very slow.

1.1.1. Trichloroethane (trade name Genklene) T.L.V 350. The toxicity rating is just high enough, and its rate of evaporation slow enough to be used when a totally enclosed plant is not available, but good extraction is essential. It is a much more aggressive solvent than the others mentioned although in practice it is rare to find it move dyes in museum objects. It is not used in the trade, since it would be difficult to control its effect on the mixed loads handled by most commercial cleaners. It is also not very stable in continual use having a tendency to hydrolyse in the presence of moisture. Stabilisers are added both to prevent the formation of acid and neutralise any that does form.

V & A experience has been that with regular distillation and topping up with fresh solvent this has not been a problem, but this addition of unknown constituents is, perhaps, the greatest disadvantage of Genklene.

1.1.2.trichloro 1.2.2.-trifluoroethane (trade name Arklone 113). T.L.V.1000. Very fast rate of evaporation. Very stable in continual use.

This is the solvent which is fast becoming the favourite in the trade for all high class work. Most of the accessories found in relation to garments - suede, leather, furs, and many plastics, are safer, as are most dyes. On all points this would be the solvent to choose as long as a totally enclosed plant is available. The rate of evaporation would otherwise make it highly uneconomic.

Cleaning Power and Detergents

The addition of detergents to a solvent, which is basically designed to dissolve oils and greases, broadens the types of soiling which can be removed. When an emulsified type of detergent is used a charge of water is carried into the system, which will aid the removal of water based stains, but will also, if the percentage is too great, affect fabrics in the same way as water during wet-cleaning.

The composition of detergents is a closely guarded trade secret and therefore conservators have to take on trust the assurances we receive from the trade that they are harmless.

Any detergent that is added must be rinsed out thoroughly with clean solvent. In practice this means great difficulty in being sure of removing all traces unless the cleaning cycle includes redistillation and a good supply of clean solvent. The conservation workshop in Blackburn does add a detergent to the Genklene used in open trays. The quantities involved are small - 0.1% of detergent - and the largest amount of solvent ever used at one time was 75 litres. The average would be 10 litres. On occasions the rinsing solvent has been saved and re-used for the first clean of the next object but generally all used solvent is disposed of, which is, of course, very expensive.

So far it has not been possible to use a detergent in the V & A machine but it may be possible in the future. Certainly experience has shown that the addition of the detergent increases the cleaning power. I.C.I. have provided two kinds - one to deal with silks and wools and the other to help clean cellulose fibres which are not usually greatly improved by solvent alone.

The practice in Scotland is to add the usual detergent provided for use with Arklone[3] in a quantity determined by the amount and nature of the soiling on the object. An emulsified form is added when there are water based stains to deal with.

Retention of Solvent and Detergent in Fibres

The general opinion of the meeting was that under laboratory conditions it would be possible to measure the level of retention in different fibres and in any fatty acids and oils present. The amount involved would be only fractions of a part per million and it was thought that at such a level it was unlikely that a) any damage would result, or that b) research would be able to detect and disentangle those changes resulting from dry-cleaning from all the other variables present. Artificial ageing tests would have little meaning in this context.

Drying and the Use of Heat

It is usual to assist the rate of drying by the use of heat both for speed and to ensure the complete recovery of solvent back into the system. For museum objects it is desirable to reduce any heat to the minimum and the R.S.M. usually use a temperature of no more than 30°C during the drying cycle.

In the V & A system heat is not used at all. One of the great difficulties is to stop patchy drying which can cause "ringing". The limitations on the size of object handled are greatly increased by this difficulty.

Drying objects cleaned in white spirit can take a very long time and the residual odour even longer to evaporate. Good ventilation and the draught of air will help but if using electric fans the flammability of this solvent could be dangerous.

Mechanical Action

The mechanical engineer at the meeting would have been very happy and willing to design the machine of every conservator's dream - at a cost. In practical terms the only viable method would be to adapt an already existing machine. The basic design of the machine used by the R.S.M. is very flexible and provides its own programmes for many variations of action. A larger door than usual gives comparatively easy access to the chamber, and a number of modifications developed by the users have cut down the possibilities of damage to objects while still providing sufficient action to shift dirt.

The V & A machine provides an entirely different kind of action but which has proved both efficient and safe. However, it would be very difficult to fit it into any existing machine and the cost of building a system into which its up and down motion of a basket through the solvent could be fitted would be astronomical.

Discussion of all the various points was very exhaustive but it was obvious that it would be a very long time before definitive answers to our questions became available. The situation concerning our choice of whether to dry-clean or not was aptly summed up by Anne Moncrieff in her report of the meeting.

"Oxidation of textiles will continue whether we clean them or not, and it was pointed out that the concern for possible damage due to one, or a few, dry-cleaning treatments should be put into the perspective of photo-degradation being the main factor in the deterioration of textile fibres, and that it dominates all other factors."

Practice

With the withdrawal of all the costumes which had been on show in the V & A Costume Court for 20 years or more the Conservation Department was faced with an emormous cleaning problem. Six dresses from the 18th century which are particularly important, but which presented special difficulties for cleaning, were taken to Edinburgh to be cleaned in the R.S.M. machine. The results gave varied degrees of satisfaction and showed that the development of technique would be an important factor in real success.

Another problem faced by the Conservation Department in 1980 was the cleaning of an early 18th century embroidery (approx 6.5m x 3.4m) which had been rescued from a fire many years ago. The woollen parts of the embroidery were deeply ingrained with dirt from the smoke. It proved impossible to wash it, because of fugitive dyes; but it had to be cleaned somehow. Using white spirit and a construction made up from bits of embroidery frames, rollers and scaffold boards the object was cleaned in the garden at Osterley. The results would have been better if it had been possible to spend more time on each section, but the effects of the fumes on the conservators were such that it would have been unwise to continue longer.

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81/9/3

THE USES FOR ORGANIC SOLVENTS IN TEXTILE CONSERVATION

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THE USES FOR ORGANIC SOLVENTS IN TEXTILE CONSERVATION

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Organic solvents can be used in textile conservation for dry-cleaning, spot removal; assistance and acceleration of evaporation and penetration of moisture; and dissolving of resins for reinforcement of weakened textiles. Each of these potential uses are discussed in outline and suggestions are offered for the selection of solvents for use.

This paper investigates the possible and actual uses of organic solvents in textile conservation. The topics discussed include dry-cleaning, dry-cleaning solvents, solvents for spot and stain removal, and solvents for carriers of solvent-soluble resins.

The use of organic solvents as a substitute for water has many advantages. Water can act as a solvent for many dyestuffs, resulting in color loss on exposure; finishes can be radically altered by moisture; fibers can swell or distort on exposure to water and serious dimensional losses can occur. Organic solvents can have none of these effects yet these same solvents can remove soils and produce significant esthetic improvement in textiles.

Potential Value of Dry-cleaning Textiles

The value of dry-cleaning textiles undergoing textile conservation can be evaluated by a study of the soils to be found on the artifact and the desirability of removal. A well-known study by Sanders and Lambert (1) analysed "natural" dirt as found in a number of American city streets and found a water-soluble component of 11 percent to 15 percent and an ether-soluble component of 4.9 to 12.8 percent. (9.0 percent average for ether-soluble soils.)

If it can be assumed that soils on textiles may follow this model, only an average of approximately 9 percent of the soils found would respond to the use of organic solvents for dry-cleaning. While this percentage does not seem high, other particulate soils that are insoluble in water can range as high as 50 percent. This suggests that vacuuming of textiles can be the most effective soil-removal method for textiles. Therefore, vacuuming and dry-cleaning can be combined to great advantage, especially if a solvent-soluble soil is present in great quantity. If the solvent-soluble soil is visually troubling, dry-cleaning can produce dramatic results.

This suggests that a potential dry-cleaning candidate would have to be evaluated to determine if solvent treatment would be of benefit. For example, a silk velvet altar frontal may have wax encrustations, inorganic particulates, sebaceous soils from handling, wine stains and aerosol staining from incomplete hydrocarbon combustion.

The array of soils listed would not be uncommon. Dry-cleaning with a typical solvent would lessen the candle wax, the sebaceous material and the aerosol hydrocarbon soil. A suitable solvent could remove all of the material with the exception of the carbon that would be found in the aerosol. Any other soils would have to be treated in another manner or remain on the textile. Therefore, it can be seen that dry-cleaning can play a major role in textile cleaning for conservation.

It may be that the removal of solvent-soluble soils produces such an effect that no further treatment is desired. This may often be the case when wet-cleaning is not possible or ill-advised. Unfortunatel those soils soluble in water do not respond to the dry-cleaning methods possible for textile conservation. Only commercial operations can provide the means to lessen water- and solvent-soluble soils simultaneously.

The advantage of solvent-cleaning is in the removal of soluble soils; a degree of relaxation of the fibers induced by the lubrication of the interstices of the fabric by the solvent; some lessening of insoluble particulates removed by fabric movement and the avoidance of the effects of water. It should be noted that as the percentage of soil likely to be affected by solvents is small and major visual improvements would be unlikely.

The Common Dry-cleaning Solvents

The solvents readily available for solvent cleaning are listed below. Any solvent chosen for dry-cleaning should be volatile, clear in color, possess a high flash point and have little or no effect on textiles, dyes or finishes. Three solvents known to have these properties are listed:

1. Stoddard Solvent. This solvent is compounded of any number of organic solvents to meet a commercial standard of ten specifications. It is flammable but has a flash point of 100 degrees farenheit. This also suggests that it is not highly volatile. It is toxic orally and the O.S.H.A. standard recommendation for exposure is 500 ppm in the air.

2. Trichloroethylene. This low-boiling solvent is nonflammable. It is relatively expensive when compared to other solvents. The fumes are narcotic and the <u>Registry of Toxic Effects of Chemical Substances</u> (3) lists an O.S.H.A. and NIOSH recommendation of 100 ppm in the air.

3. Tetrachloroethylene. This solvent, also known as perchloroethylene appears to be the more common dry-cleaning solvent among commercial cleaners. It is not highly volatile and also has the advantage of nonflammability. The NIOSH recommendation for exposure is 50 ppm in the air. (4).

Another solvent was introduced in the 1960's for use in coin-operated dry-cleaning machines. Commonly, it is known as Trichlorotrifluoroethane. It is less reactive than the common solvents listed above and is said to have little or no effect on plastics, plasticizers or rubber. This makes it ideal for use in unrestricted coin-operated machines.

The Use of Solvents in Spot-Removal

The removal or lessening of spots with solvent treatment can only occur, of course, when the soil is soluble in the solvent. If the soil is unaffected by the solvent chosen, other solvents can be investigated. Often too, heat can increase solubility of the soil. Conservators may wish to have an assortment of solvents on hand for experimentation.

The range of potential soils that may be found as spots could include natural or synthetic lubricants, resins such as white glue or other adhesives, drying oils such as linseed or tung oil and the wide range of paints, sealers and varnishes and so on.

The selection of solvents for spot-removal experiments should be based on the widest possible use of the chemicals. A number of classification systems are in use and the literature of the paint industry offers ample documentation. The simplest division seems to be that based on hydrogen bonding: poorly hydrogen-bonded; moderately hydrogen-bonded; and strongly hydrogen-bonded solvent. As an example, a very brief list of solvents is shown below (5):

Poorly Hydrogen-Bonded	Moderately Hydrogen-Bonded	Strongly H-Bonded
toluene	diethyl ether	ethanol
n-heptane	dioxane	methanol
dichlorobenzene	acetone	cyclohexanol
zylene	ethyl acetate	glycerol
chloroform	methyl cellosolve	n-propanol

In addition to the grouping by hydrogen bonding, a more quantitative method exists for grouping solvents by "solubility parameter." (6). By calculating a delta value, solvents are assigned a solubility parameter of a whole number or delta value. This provides a further classification and extensive tables of delta values are available (7).

This classification system provides a method of selecting a wide but effective range of laboratory solvents for spotting use. For example, a conservator may select four solvents from each hydrogen-bonding group by examining the delta values and choosing solvents with solubility parameters that do not overlap.

Poor H-bonding	delta	Moderate H-bonding	delta	Strong H-bonding	delta
methyl-cyclohexane	7.8	diethyl ether	7.4	ethanol	12.7
toluene	8.9	amyl acetate	8.3	methanol	14.5
dichloro-benzene	10.0	dioxane	9.9	glycerol	16.5
chloroform	10.3	dimethyl-phthalate	10.7	water	23.4

By examining the table above, it can be seen that none of the delta values of the solvents are the same. In this way, the maximum use of the solvents can be derived. In substance, the maxiumum number of solubles can be dissolved with this array of twelve solvents. For example, if acetone had been selected as one of the moderately H-bonded solvents, its delta value would have overlapped with that of dichloro-benzene, both solvents having a solubility parameter of 10.0. It should be stressed that the solventslisted in these tables are selected for illustration only and not for recommended use. Careful reading of the literature prior to solvent selection is highly recommended.

Once the solubility parameter and hydrogen-bonding tables are consulted, solvents can be selected for maximum dissolution power and safety. Difficult paint stains and oily soil encrustations can be made to respond to a single solvent or perhaps, a combination of two solvents. The benefit of the spotting process is apparent. The textile is spared total immersion and in some instances, the textile can be treated on site as in the case of upholstery and related problems.

Solvents in Water-soluble Soil Removal

One of the major drawbacks in wet-cleaning is the effect of immersing the textile into water. In an effort to minimize wet-cleaning, the spotting of water-soluble soils may be undertaken. This spotting often produces a complication of a spotting ring caused by the wicking of the moisture outward from the spot. This wicking often carries soil with it. The less wicking, the smaller the potential spotting ring.

To lessen wicking, a faster evaporation of the water can be induced by blow-drying and tamping with dry cloths. By the use of strongly hydrogen-bonded solvents such as ethanol, propanol or methanol mixed in selected ratios in water, evaporation and drying can be greatly accelerated. Alcohols which are easily miscible with water are the logical candidates for such a technique.

Informal experiments with alcohol/water mixtures in spotting, water-soluble adhesive removal and dyestuff retouching have been carried out and it has been noted that ratios of alcohols higher than 50 percent lessen the effect of water to a serious degree. It would seem to be impossible to give firm figures to ratios as so many spotting and adhesives problems are encountered.

Alcohol/water solutions would seem to be a promising technique for some wet-cleaning tasks and the practice should be investigated in the future. The use of the higher alcohols might also be attempted in this practice.

Solvents Used in Reinforcing Resins

The use of soluble resins for the reinforcement of weakened textiles is popular with a number of conservators. The solvents for these resi are usually accepted without question. However, a number of the polyamide and vinyl-based resins are soluble in safer solvents than zylene and/or toluene. A good deal more attention should be paid to the safety of these solvents, especially when they are used in spraying. A number of alternatives exist for placing these popular resins in solution and they should be explored.

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THE PREVENTION OF SOIL REDEPOSITION IN THE CLEANING OF HISTORIC TEXTILES

Anthony W. Smith and Marion H. Lamb

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ABSTRACT

This paper results from the close co-operation between conservators and scientists in the assessment of industrial research. As the cleaning of historic textiles is a crucial part of the textile conservator's work it was decided to investigate washing solutions. This paper focuses on the soil anti-redeposition agent sodium carboxymethyl cellulose (CMC).

The problems and theory of soil redeposition, the increased hazards involved in using hard water for washing, and the properties of CMC, precede recommendations for its use (including the importance of choosing the right grade). The paper concludes by recommending three ways of minimizing the problem of soil redeposition in the cleaning of historic textiles.

Introduction

In the formulation of detergents for use in cleaning historic textiles, sodium carboxymethyl cellulose (CMC) has been recommended as an anti-redeposition agent (1). However little guidance has been given on the choice of a suitable grade for washing textiles. In order to establish which grade and concentration of CMC would provide optimum anti-redeposition performance, a survey of the relevant research literature was undertaken.

This paper outlines the theory of soil redeposition, the commercial detergent manufacturers solution to the problem, and the application of their research to the cleaning of historic textiles. The mechanism of detergency has already been described (1,2,3).

This paper is concerned with the role of anti-redeposition agents used in modern detergent formulations.

The problem of soil redeposition first received attention in the 1940's when synthetic detergents began to replace soaps as the major textile washing aids (4). It was noted that white cotton textiles that had been washed in synthetic detergents were not as white as those washed in the traditional soap solutions. This was eventually explained by the fact that although the synthetic detergents were very effective at removing soil from textile fibres they were not very good at holding it in suspension.

Consequently, the soil was being redeposited on the fibres before it could be removed from the wash bath. Redeposited soil is extremely difficult to remove from textile fibres, so that repeated washing will lead to a build up of soil on the fibres, which is then seen as a general greying of the cloth.

The redeposition problem was finally overcome by the addition of small quantities of the water soluble polymer CMC to detergent formulations (4). This derivative of cellulose was found to have excellent anti-redeposition properties and to greatly enhance the whiteness retention of cotton washed in all types of detergents, including soaps. Many other water soluble polymers have also been investigated for their anti-redeposition properties, but only a few, such as polyvinyl pyrrolidone and polyvinyl alcohol, can approach the efficiency of CMC (5).

The theory of soil redeposition

When immersed in water, both fibres and soil particles acquire negative electrical charges on their surfaces (1,2,3,5). Since like charges repel, soil particles will be repulsed from the surface of fibres and from each other. In opposition to the repulsive forces, various mechanical, chemical and electrical forces may operate to cause deposition and retention of soil during detergency. For instance, soils which have lost their greasy or oily coatings and have been broken up into fine particles by the detergent bath, will adhere very tenaciously to the surface of fibres. Having a high surface to volume ratio, they present a large surface area to the fibres. In particular, Van der Waal's attractions, or dispersion forces, which only operate over molecular distances, become strong enough to bind the particles to the fibre surfaces.

Particles of less than 0.2 microns (0.2×10^{-6}m) diameter are said to be nearly impossible to remove by laundering (6). Even those of 5 microns diameter may cause problems. The lodging of particles in small surface irregularities, called 'micro-occlusion', and hydrogen bonding between the natural fibres and certain soils, such as proteins, have also been cited as possible mechanisms of soil retention (1,5).

In the presence of cations (positively charged ions), soil particles held in suspension will tend to clump together, or 'flocculate'. As the clumps of particles become bigger suspension becomes more difficult. Hence, flocculation will lead to an increase in redeposition (5).

If salts of sodium or potassium are added to the wash bath, redeposition is increased as the concentration of the monovalent cation (Na^+, K^+) is increased (7). However, the effect is not serious and can be readily corrected by the use of an anti-redeposition agent (See below). As the valency of the cation increases, so its flocculating power also increases. Therefore, polyvalent cations, such as calcium (Ca^{++}), magnesium (Mg^{++}), and iron (Fe^{+++}), will greatly increase flocculation of soil particles and hence, redeposition (1,5,7).

These polyvalent cations will also act as bridges between the negatively charged soil particles and the negatively charged fibres, effectively binding the soil particles to the fibre surfaces (1).

Consequently, the presence of calcium, magnesium and iron salts in washing water is a major factor in soil redeposition.

Hard Water

Tap water usually contains varying amounts of calcium, magnesium and sometimes iron salts, the concentration of these salts being high in so called 'hard' water. To combat hard domestic water supplies, household detergents always contain a sequestering agent, such as sodium tripolyphosphate or sodium ethylene diamine tetra-acetate (EDTA), to 'lock-up' the polyvalent cations in water soluble compounds and so render them harmless (4). However, it should be remembered that no matter how much sequestering agent is added to household washing powders the rinsing stage of washing will be with tap water, including the final rinse. The presence of polyvalent cations during rinsing may lead to soil redeposition and retention. In addition, if the final rinse is in tap water, salts may be deposited in the fibres.

When washing historic textiles, the use of tap water, even in 'soft' water areas, is highly undesirable for the reasons given above. All water used throughout the washing procedure should be either passed through a water softener unit, which replaces calcium and magnesium ions with sodium ions, or a de-ionizer. Ideally, the final rinse should be in de-ionized water, so that no salts are left behind in the fibres.

CMC

A further step in reducing redeposition can be made by the use of an anti-redeposition agent such as CMC. Extensive research has now firmly established that CMC is adsorbed on both cellulose fibres and soil particles during the washing operation (8).

Since CMC is an anionic polymer it will carry many negative charges in water. Therefore, the normal electrical repulsion between fibres and soil particles will be greatly enhanced by the adsorption of CMC. This has the effect of reducing redeposition to a minimum.

CMC is a cellulose ether, produced by reacting 'alkali' cellulose with sodium monochloroacetate ($ClCH_2COO\ Na$) under regidly controlled conditions. Each anhydroglucose unit of the cellulose chain contains three hydroxyl (-OH) groups. By substituting carboxymethyl ($-CH_2COO^-Na^+$) groups for some of the hydrogens of these hydroxyl groups, sodium carboxymethyl cellulose is obtained.

For example:

$$-\overset{|}{\underset{|}{C}}-OH + Cl-CH_2-COO^-Na^+ \rightarrow$$

$$-\overset{|}{\underset{|}{C}}-O-CH_2-COO^-Na^+ + HCl$$

carboxymethyl group

The average number of hydroxyl groups substituted per anhydroglucose unit is known as the 'degree of substitution' (DS); a DS of 3 not being obtained in practise. CMC is produced in a range of molecular weights; as the molecular weight increases, the viscosity of CMC solutions increases rapidly.

Choosing the correct grade of CMC

It is very important to choose the correct grade of CMC if the maximum anti-redeposition properties are to be obtained.

Research has shown that the best results are obtained when using CMC with a DS of 0.6 - 0.8 and a degree of polymerization between 200 to 500 (which corresponds to a molecular weight of about 90,000) (5,8). CMC of this molecular weight range would be of a low viscosity type. The amount of CMC added to household washing powders usually corresponds to between 0.5 to 2% of the total weight of the powder (4,5). The concentration of CMC in the wash bath will be about 0.005% (ie 0.05g of CMC per 1000 ml of washing solution). For washing historic textiles a similar concentration of CMC would seem to be applicable.

Conclusion

The redeposition of soil seriously reduces the efficiency of detergency and may cause irreversible soiling of textiles. The following steps may be taken to minimize the problem when washing historic textiles:

1) Use only softened or de-ionized water for all stages of the washing procedure;

2) Add 0.05g of CMC*per 1000 ml of washing solution (ie., 0.005% concentration);

3) Never allow the wash bath to become too loaded with soil, repeated detergent baths can accomplish better soil removal with much less opportunity for soil redeposition.

* It is important to use the correct grade:

low viscosity CMC with a DS in the range 0.6-0.8 for example

"Hercules 7L" from the Hercules Powder Co.Ltd.

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81/9/5

ON THE APPLICATION OF ACRYLIC POLYMER FOR LINING OF ANCIENT TEXTILE

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ON THE APPLICATION OF ACRYLIC POLYMER FOR LINING OF ANCIENT TEXTILE

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There are presented the results of investigations of the polymer properties change in the process of artificial light-heat ageing, of its sticking-power, its influence on textile fabrics. On the basis of the obtained data the technique of fabric lining with acrylic polymer A-45K is proposed.

Introduction

One of the complex and important problems of the museum textile conservation is the lining of fabrics. Widely used natural glues of animal and vegetable origin possess essential drawbacks : in the course of time they become rigid, brittle, lose their sticking-power, decrease their resistive capability against moulds and bacteria. The application of new adhesive materials requires great carefulness and thorough investigations. The museum restoration practice presents the following requirements to the polymeric adhesive materials:

a) polymer and its solvents should be inert to the

materials of the work of art- not to destruct tissue, not to change colours;

b) adhesive polymers should posses stability against the process of ageing: under the influence of light, temperature and humidity fluctuations not to change its physico-mechanical and chemical properties and, what is especially important, polymer should be reversible;

c) the lining process should not change the artistic expressiveness of the work (hue, texture, elasticity).

The task of our work is to study possibilities of applying new polymeric materials for lining fabrics. During the first stage of the experimental work 15 polymers and copolymers of vinyl and acryl series were selected. We carried out a number of preliminary experiments with the aim of selecting solvents, concentrations, viscosities, we investigated polymer mixtures. The sticking-power and rigidity of the lined samples for all the polymers were determined.

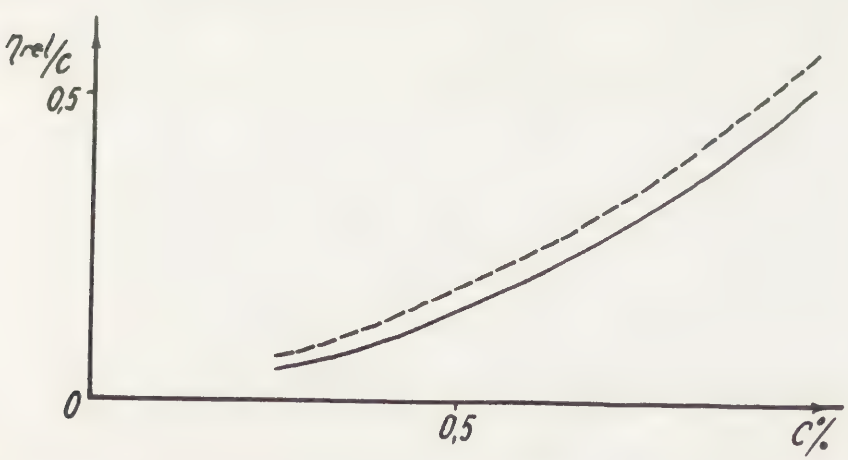
The best results were shown by the copolymer of vinylacetate, butylacrylate and acrylic acid A-45K. The polymer dissolves in acetone, esters, toluene, Its film is colourless, transparent, very flexible and not glittering. Furthermore, we investigated the properties of this polymer in detail, its influence on the object under restoration, we worked out the methods of lining.

Experimental

The polymer durability was determined by the method of accelerated light-heat ageing and it was evaluated by changing its physico-mechanical properties. The films of the polymer were exposed to ageing under mercury-quartz irradiator ПРК-7 at the temperature of 70° C and by damping in the course of 70 hours (ГОСТ 8979-79; ПРК-7 power 1000w , spectral characteristic :

257.8 - 398.4 nm	-	46.7 %
404.7 - 690.7 nm	-	40.7 %
1014 - 1711 nm	-	12.6 %

0.05, 0.1 and 0.25 % solutions of the polymer film were prepared for determining relative viscosity. After the light-heat ageing polymer A-45K preserved the capacity for dissolving in the corresponding solvents, i.e. it is reversible. The concentration dependence of viscosity of the polymer solutions before and after ageing is shown in fig. 1.



The acidity of the polymer solutions in the mixture of dimethylformamide water (1 : 9) was measured. Ageing leads to an insignificant acidification of the polymer: initial pH - 4.7, after ageing pH-4.2. This probably , is the consequence of destruction accompanied by the isolation of acidic products.

The polymer film didn't change visually in the process of light-heat ageing- it didn't turn yellow, it remained colourless.

The newly formed films and also the aged specimens appeared water-resistant: they can long remain in water without any visual changes-turning white, cracking.

The sticking-power of the polymer and the rigidity of the lined samples are the essential indices under fabric lining. For the evaluation of the polymer sticking-power the resistance to lamination by the technique ГОСТ 10550-75 with the dynamometer ZT-4 was determined. The rigidity of the lined specimens was tested with the apparatus ПЖУ-12 by the technique ГОСТ 8977-74. The experiments were carried out with the samples of natural silk lined on dederon. Resistance to lamination and rigidity were being determined on newly lined and on aged samples (Table 1) .

Table 1

Resistance to lamination and rigidity of lined specimens

Lining glue (adhesive)	Resistance to lamination		Rigidity (CN)	
	Specimens before ageing	Aged specimens	Specimens before ageing	Aged specimens
A- 45K	2320	388	2.1	2.0
wheat-flour glue	15	10	2.5	2.0

In parallel, the lined specimens were investigated from the point of view of air permeability. The polymer appeared to remain air permeable in the process of ageing air permeability 1820 dm^3/m^2 sec.)

The influence of the polymer on fabric strength was investigated. The physico-mechanical properties of a fabric-breaking strength and elongation at break-were determined with the breaking machine PT-250 OMZ by the technique ГОСТ 3813-72. Three types of fabrics were investigated· wool, silk and cotton. Fabric strips were submerged into the polymer solution.The impregnated specimens were exposed to light-heat ageing. The obtained results showed that the polymer didn't influence the fabric strength and even delayed the ageing of textile material (Table 2).

Table 2

Change of physico-mechanical properties of fabrics in the process of ageing

	Silk		Wool		Cotton	
	Breaking strength (kg)	Elongation at break %	Breaking strength (kg)	Elongation at break %	Breaking strength (kg)	Elongation at break %
Not aged fabric	12.8	13.0	-	-	25.5	25
Aged fabric	1.2	2.5	9.4	10	13.6	10
Aged fabric A-45K	3.6	5	17.6	11	20.8	11

The ageing process of textile materials processed with polymers was investigated by means of the infrared absorption spectography method. IR spectra were recorded with infrared spectrophotometer IP-10 with the help of the inner reflection element KRS-5 (Q of the refraction 45°, N-12) straight from silk bands. While preparing the impregnated specimens for spectral analysis the polymer was removed from them(Fig.2).

Changes taking place in silk specimens were determined by the changed absorption bands in the field of 3360-3280 cm^{-1} conditioned by valency oscillations of amido group in peptide linkages and in the field of 2960-2950 cm^{-1} on

IR- spectra of silk samples. 1- spectra of silk before ageing; 2- spectra of aged silk; 3- spectra of silk sample aged with polymer.

the oscillations of CH_2 group. While analysing the absorption spectra the conclusion was made that the destruction of peptide linkages and the appearance of NH_2 take place in the process of silk ageing. The spectra of silk samples the ageing of which was carried out with the polymer almost don't differ from the specimens of not aged silk. While analysing the absorption spectra of cotton specimens no essential changes in the ageing process of the samples with the polymer and those without it were observed.

proceeding from the data of spectral analysis and also from the study of physico-mechanical properties of the fabric one can suppose that the acrylic copolymer forms a film on fibrous material that keeps on the fabric due to its physical and mechanical forces. Firmly fixing itself on the fabric it comparatively firmly attaches other tissues to the fabric.

Application and conclusions

On the basis of the obtained results a conclusion was done on the possibility of the polymer A-45K application for lining fabrics.

In the result of numerous tests with the specimens a convenient to our opinion lining method was proposed: the polymer A-45K 6-10 % solution in acetone is prepared in the form of aerosol. Adhesive is deposited on the lining material 2-4 times with the intervals for drying. The fabric under restoration is superimposed on the material

and then it is ironed (60 - 80° C) through a silicon and flouroplastic film.

It should be noted that it is impossible to present a common method of lining fabrics.In every case an approach must be individual depending on fabric, destructions and many other factors.

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TEINTURE EN ROUGE DES TISSUS DE DOUBLURE

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Comité pour la conservation de l'ICOM
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Groupe de travail: Textiles

TEINTURE EN ROUGE DES TISSUS DE DOUBLURE

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L'exposé porte sur l'histoire de l'application de la cochenille de l'Arara (Porphyrophora hamelii Brandt) dans l'antiquité et sur les résultats des études des caractéristiques de la cochenille d'Arara permettants la recommendation de la cochenille d'Arara pour la teinture des tissus de doublure.

Utilisation de la cochenille de l'Arara pour la restauration des tissus anciens.

Dans la section des Arts Appliqués du Centre scientifique fédéral de restauration artistique au cours des dix dernières années on a effectué un travail scientifique pour selectionner des colorants naturels et synthétiques qui, par leur qualité de teinture et leur résistance, pourraient servir à la coloration des tissus de doublure.

Les artistes qui s'occupent de la restauration

des tissus anciens se sont intéréssés à la cochenille, antique colorant rouge, connu pour l'étonnante capacité qu'il a de laisser sur les tissus en fibre d'albumine, des laques teintées, remarquables par leur résistance, la variété et le coloris de leurs nuances.

Le travail ci-joint est consacré à la manière d'utileser la cochenille de l'Arara pour la restauration des tissus anciens. L'emploi de la cochenille permet aux restaurateurs de compléter la gamme des colorants employés pour la teinture des tissus de doublure et de rapprocher au maximum leur coloris de celui des originaux, teintés autrefois avec la cochenille.

<u>Donnés générales sur la diffusion et sur l'emploi de la cochenille de l'Arara comme colorant</u>.

Depuis l'antiquité, la cochenille a été utilisée par les hommes pour colorer les tissus, les cuirs, les papiers, les cheveux, les boissons. L'acide carminé $C_{22}H_{20}O_{13}$, dérivé de l'antrachinon est la substance colorante de la cochenille.

Selon les renseignements actuels (1), il existe sur le territoire de l'URSS, 13 sortes de vers dont le plus précieux grâce à la qualité des ses coloris est la cochenille de l'Arara (Porphyrophora hamelii Brandt).

La cochenille de l'Arara habite dans les rhizomes des graminées, Aeluropus littoralis, et roseaux qui poussent sur les terrains salifères. Elle a un corps ovale de 3 à 12 mm de longueur sur 6 mm de largeur. Sa couleur est rouge cerise sombre.

On a conservé de nombreux témoignages sur l'utilisation de la cochenille comme colorant dans l'Antiquité. Par exemple dans le "Livre des routes et des empires"(vers l'an 930 environ) il est question de la ville de Dabilé (plus tard Dvina), capitale de l'ancienne Arménia: "Dans cette ville sont fabriquées des robes de laine, des tapis, des coussins, des sièges, des cordes et d'autres produits de fabrication arménienne. Ils sont d'une couleur appelée "kirmiz" dont on teint la toile (2).

A la fin du X-ème siècle l'écrivain arabe Al-Moukadassi donne des renseignements intéressants sur la récolte de la cochenille: "On trouve là de la "kirmiz". C'est un petit ver qui vit dans la terre, les femmes s'en approchent le recueillent avec soin dans des recipients de cuivre et le font sécher dans les fours à pain" (3).

Le Caucase et la région de Derbent sont connus comme des lieux de production et des centres d'exportation des genres de colorants les plus précieux, utilisés pour la soie et la laine. Selon A.S.Ivanov (4) qui a étudié les documents concernant l'histoire de la fabrication des tapis dans Caucase oriental,

l'exportation de la cochenille et de la garance n'a cessé de crôtre jusqu'au milieu du XIX-ème siècle où elle a atteit 300 000 pouds par an. La qualité de la fabrication était alors meilleure que jamais. M.Chopen qui a voyagé dans le Caucase, décrit ainsi l'abondance de la cochenille en Arménie au XIX-ème siècle: "Dans certains endroits elle se trouve en si grandes quantités que la terre apparait comme un tapis, émaillé de dessins rouges. Le bétail qui paisse par là, a les pattes comme peintes en rouge par les cochenilles qu'il piétine" (5).

Comme tous les colorants naturels, la cochenille de l'Arara a été ensuite complètement évincée par les premiers colorants cynthétiques dont le manque de résistance s'est tout de suite fait sentir dans la qualité des tapis et des tissus de soie.

Expériences.

Selon les donrés de l'analyse, la cochenille séchée conserve jusqu'à 30% de lipides, c'est à dire de substances graisseuses. Pour prévenir une précipitation possible de ces substances sur le tissu à teindre, on procéda à un dégraissage préalable de la cochenille en extrayant les lipides avec des dissolvants organiques. On utilisa dans ce but le système monophasé des dissolvants du chloroforme, le métanol

(en volume 1 de chloroforme sur 2 volumes de méthanol)

On procéda à la teinture à la cochenille selon la méthode pour la coloration des tissus de doublure, c'est à dire avec des colorants végétaux naturels et l'emplois des mordants (1). Comme mordants on choisit les sels de minéraux suivants: aluns aluminopotassiques, aluns chromopotassiques, sulfate de zinc, sulfate de cuivre, chlorure d'étain, sulfate de fer (oxidé ou protoxydé).

La résistance de la soie et de la laine teintes était appréciée quantitativement. Les résultats furent assez positifs.

Discussion.

La coloration expérimentale de tissus en fibres d'albumine, par l'extrait de cochenille de l'Arara, prouva qu'il était possible d'obtenir toute une gamme de belles couleurs incluant le rose, le rouge, le framboise, le violet et le gris.

Des modèles connus de broderie russe ancienne ont des couleurs se rapprochant beaucoup de celles que nous avons ainsi obtenues.

Il est possible qu'à l'avenir ces couleurs puissent servir d'étalons originaux, afin de déterminer les colorants et les corrosifs utilisés autrefois.

Le résultat des expériences ont établi tempéra-

ture optimale pour la teinture c'est à dire celle à laquelle la fibre prenait au maximum la couleur, le temps d'établissement de l'équilibre dans le système: solution colorante - fibre colorée. Fondation des moyens d'application des mordants.

Pour obtenir des nuances plus profondes et plus pures, on ajoute dans le bain, du sel vinopotassique $C_4H_5O_6^-K$, connu sous l'appelation de Cremortartare. Grâce à des recettes anciennes du XVII-ème et XVIII-ème siècle que l'on a pu déchiffrer, on a appris qu'il fallait ajouter cette pierre de vin à la teinture à la cochenille (7,8).

Conclusion.

1. Les recherches faites ont prouvé que la cochenille de l'Arara était un colorant naturel irremplaçable pour la teinture de la soie et de la laine.

2. Les extraits hydratés de cochenille permettent de teindre la soie et la laine en mauve, rouge, framboise, violet, gris. Les couleurs obtenues sur de la soie et de la laine préalablement traitées sont d'une assez grande résistance.

3. Grâce à la qualité des ses coloris et à sa résistance caractèristique, la cochenille de l'Arara (Porphyrophora hamelii Brandt) peut être employée pour la teinture de la laine dans la restauration

des tissus anciens.

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81/9/7

THE USE OF TANNINS IN ANCIENT TEXTILES

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Working Group: Textiles

THE USE OF TANNINS IN ANCIENT TEXTILES

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SUMMARY

We have characterized gallo- and ellagotannins in a series of ancient textiles.These substances must certainly be ranged between the dyeing materials of prime importance:the dyers have always used them,even when they were strongly prohibited.

INTRODUCTION

The use of tannins is known since early times not only for the manufacture of leather and of inks but also for the dyeing of textiles.FLIEDER and all published recently a series of interesting papers in the field of inks[1,2,3].This was an encouragement for us to study tannins in ancient textiles.

Several problems make the identification of these compounds very difficult.They consist of complex mixtures of polyphenolic compounds attached to sugars;they are so widely occuring in the plant kingdom that it is practically never possible to recognize a definite plant in an unknown sample;furthermore,we shall show here that the dyeing and ageing processes have a strong influence on the composition of the mixture.

EXPERIMENTAL

Preparation of the samples

Crude tannins

The samples are hydrolysed with hydrochloric acid according to the method described in (1) ,in order to separate the phenols from the sugars: 0.3 mg tannins are heated in stoppered tubes with 3 ml aqueous HCl(3%) at 105°C for 4h.The solution is then evaporated to dryness and the residue is dissolved in 1 ml methanol.

Dyed wool from tapestries

The little bits of wool are treated in the same way except that the hydrolysed residue is redissolved in water.It is then extracted by ethylacetate in order to eliminate the water soluble impurities.

Dyeing of wool

1 g wool is mordanted with 0.02g ferrous sulfate during 30 min. at boiling temperature.1g tannins are added after cooling.The bath is then put to the boil during 30 min.

Artificial ageing

Artificial ageing is performed with a Xenon lamp of 6000 W(250.000 lux) during 24h,93h,160h,207h,256h and 329h.

Thin-layer chromatography

Tannins are separated on silicagel sheets (60 F 254, Merck) using the solvent mixture ethylacetate,chloroform, formic acid(4/5/1),(3,4,5).After an elution of 6cm ,the plates are dried and sprayed with 2-aminoethyldiphenylborate (Fluka AG, Buchs SG, Switzerland,N° 42810). The spots are observed under U.V. light (350 mμ),(TableI)

Reversed-phase high performance liquid chromatography(*)

The apparatus is a Perkin-Elmer series 2 with a microprocessor Sigma 10 and a Rheodine valve injector. The detector was fixed at 254 mμ.The columns(30 cm x 10u I.D.)were packed with the Microbondapak C18 reversed phase of Waters Associates and run at 35°C.
The samples are diluted in tetrahydrofuran in order to reach a concentration of about 1μg/μl.The separation is accomplished by elution with the mixture methanol+eau (45/55) with a flow-rate of 1ml/min.

(*)These experiments were performed in the laboratories of the firm LABAZ,Brussels,by Mr J.PITTIE.

RESULTS AND DISCUSSION

Table I enumerates the different fractions which have been separated by the thin-layer chromatography of a series of hydrolysed tannins. It illustrates the complex composition of these substances[2,6,7].Ellagic acid (Rfx100=20) and/or gallic acid(Rfx100=55) are clearly identified in most extracts.
The numerous other fractions which are also present could afford the charaterization of each tannins.

Unfortunately, the extracts of dyed wool give not the same results.Ellagic and gallic acid are the only components which remain visible.SIMPSON[8] has pointed out that the uptake of tannins by wool is quite limited: between 0.15 and 3%. This is perhaps the reason why minor components are no more detected in wool extracts.

The artificial ageing of wool which was dyed with sumach confirms the stability of gallic acid.

The detection limit of H.P.L.C. is in the same order of the performances of thin-layer chromatography ,at least with the experimental conditions we used.

It follows that this analysis cannot determine the definite botanical source of the tannins which were used for dyeing wool.Nevertheless we can class them into gallo-,ellago- or mixed gallo-ellagotannins.

Tapestries from the XVth and XVIth centuries-Tournai, Brussels,Antwerp[9,10,11,12]

DE POERCK[13] reports that ,in the Middle Ages,tannins were considered with suspicion by the dyers' guilds because of their apparent destructive effect on the fibres. As a matter of fact several rules limit strongly the use of tannins for dyeing textiles.
Nevertheless,walnut skins and roots,alder bark and roots, turkish galls... are mentioned in many recipes.When these "brunissures" or " racinages" were allowed ,they had to be followed by a dyeing with weld,madder or/and indigo. The latest rule appears to have been largely obeyed in the XVth and the XVIth centuries.

We find tannins and moreoften gallotannins in most tawny,brown and in general all dark shades of the tapestries.They are seldom used alone .In most cases, they are associated to other dyes,as the Guilds enjoined it.

The destruction of the dark brown fibres can be explained by the dyeing process: a dyeing with indigo under alkaline conditions, a long boiling with red and yellow

TABLE I: Thin-layer chromatography of tannins

Spots: Rf X 100 / color at 350 mµ / Substances	13 green-yellow	18 blue	20 green-yellow	28 blue	30 blue	35 pink	38 pink	40 blue	46 blue	50 yellow	55 blue	63 blue	66 blue	70 black	71 blue	81 pink	83 blue	98 yellow
gallic acid											+							
ellagic acid			+															
catechine	+							(+)	(+)			+						
shikimic acid									+bk									
pyrogallic acid					+bk									+				
turkish galls(Quercus infec.)			+		+						+	+						
chinese galls(Rhus semialata)				+	+					+	+	+	+					
sicilian sumach(Rhus coriaria)		+		+	+		+			+	+	+						
chestnut(Castanea sativa)			+								+							
black tea(Camellia sinensis)			+			+	+				+						+	
Knoppern nuts(Querc.pedunculata)			+															
Valonea acorn-cups(Q.valonea)			+											+				
Divi-divi(Caesalp.coriaria)			+								+	+		+				
Algarobilla(Caes.brevifolia)			+							+	+							
walnut skins(Juglans regia)			+						+						+	+		
alder bark(Alnus glutinosa)			+					(+)			(+)							
birch bark(Betula alba)			+								+						+	
pomegranate(Punica granatum) fruits, seeds or bark			+								?							
myrobalan(Terminalia chebula)			+					+			+							
black wattle(Acacia mollissima)			+								+	+			+	+		+
quebracho (Aspidosperma queb.)							+			+					+ylw			+

dyes and above all the use of iron as a mordant. It has been proved indeed that this metal acts as a strong catalyst in the photooxidations[14].

Tapestries from the XVIIth century-Brussels [15],Antwerp [12].

In the XVIIth century,the dyeing techniques undergo fundamental changes.The number of shades in the tapestries increase from about 50 in the Middle Ages to more than hundred.The "new look" is the imitation of paintings. COLBERT enacts general regulations for the dyers of the "Gobelins" where we notice the use of sumach and turkish [Aleppo] galls.

We had the unique opportunity to take samples from a wonderful series of Brussels tapestries belonging to the KUNSTHISTORISCHES MUSEUM of Vienna when they came in Brussels for the "Rubens' Year"[16].These tapestries were seldom exhibited and the samples still conserved dyestuffs which normally disappear by ageing.
We have found gallotannins and mixed galloellagotannins in most brown and dark shades.They are still associated with the classical dyestuffs like madder,weld and indigo However,new dyes take an increasing importance:redwoods replace madder,old fustic replaces weld ,although these dyestuffs were classed by COLBERT amongst the dyes of bad quality[" petit teint"].
Ellagotannins are often encountered in dark blue shades with indigo.

Tapestries from the XVIIIth century- Brussels ,Audenarde

Here again we were very privileged to have at our disposal exceptional reference samples:the MUSEE DE LA VIE WALLONNE allowed us to take samples from the recipes book of a dyer who was working in Verviers in the XVIIIth century.The samples were protected from the light between the pages and a the dyer had carefully written the weight and the nature of each products .Brown shades were mostly achieved with a mixture of old fustic,sumach, logwood and iron sulfate.Madder or a redwood mordanted with alum are also frequently added.

REVERD[17] reports the rules of 1733 which were in effect at the GOBELINS.Walnut skins and alder roots are of general use for the grey shades after a "pied de cuve" with indigo.Logwood is used for black,purple,chesnut- and plum-colors but it is still forbidden for the blue,green and violet shades.

We find indeed very frequently old fustic,tannins and redwoods in the brown samples of textiles from this time. Logwood falls often behind our limits of detection.

CONCLUSIONS

The tannins have always played a very important part in the dyeing techniques even in the Middle Ages when the Guilds tried to limit their use.This is certainly due to the fact that these subst ances are easily and cheaply extracted from a lot of vegetable species.

The evolution of the dyeing technique concerns principally the dyes which were mixed with the tannins: madder,weld and indigo in the XVth and the XVIth centuries,old fustic,redwoods and logwood in the XVIIth and the XVIIIth century. Sumach replaces also gradually walnut skins,alder bark and Turkish galls which were used in our country since early times.

This evolution had a bad consequence for the conservation of the brown shades because of the poor fastness to light of the redwoods.

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81/9/8

RESTORATION OF THE GRAVE FINDING OF THE 16TH CENTURY EXCAVATED IN THE BOLDVA CALVINIST CHURCH

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RESTORATION OF THE GRAVE FINDING OF THE 16TH CENTURY EXCAVATED IN THE BOLDVA CALVINIST CHURCH

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During the excavation executed in the monument church very precious graves of the 16.-17. centuries have been uncovered by the archeologist Dr. Ilona Valter. One of these, the finding group found in the grave Nr. 21. constitutes the subject of the paper.

The remains of a 14-16 old girl laying on a "flower bed" placed in a wooden coffin was found in the sanctuary bay. Her 2.5 m deep grave has been digged without a crypt in the earth. In the course of the excavation a Hungarian girl's headdress with a gold clasp, a false tail of hair, a gilded silver belt, and some clothes fragments came to light.

The first chapter of the paper is dealing with the circumstances of the uncovering with the lifting out, packing and transportation of the finding group, as well with the cleaning and disinfecting of this latter. The description of the finding group and the making known of the formal and technical analogies are included in the second chapter. The third chapter makes one acquainted with the principle and the working process of the restoration. The forth chapter is dealing with the general characterization of the woman wearing of the 16. century and with the dating of the Boldva finding.

During the excavation executed in the monument church very precious graves of the 16.-17. centuries have been uncovered by the archeologist Dr. Ilona Valter. One of these, the finding group found in the grave Nr. 21 constitutes the subject of the paper.

The remains of a 14-16-year-old girl laying on a "flower bed" in a wooden coffin was found in the sanctuary bay. Her 2.5 m deep grave has been digged without a crypt in the earth. In the course of the excavation a Hungarian girl's headdress with a gold clasp, a false tail of hair, a gilded silver belt, and some clothes fragments came to light.

The first chapter of the paper is dealing with the circumstances of the uncovering, with the lifting out, packing and transportation of the finding group, as well with the cleaning and disinfecting of the latter. The description of the finding group and the making known of the formal and technical analogies are inclued in the second chapter. The third chapter makes one acquainted with the principle and the working process of the restoration. The forth chapter is dealing with the general characterization of the woman wearing of the 16. century and with the dating of the Boldva finding.

The village of Boldva lies north of the town of Miskolc, in the vicinity of the meeting point of the rivers of Sajó and Bódva. The historic monument church which is the property of the Calviniste Church stands in the centre of the settlement. In the month of August of 1976, during the excavation carried out in the church very precious graves were uncovered by the archeologist Dr. Ilona Vaiter, member of the National Inspectorate of Historic Monuments.

The remains of a 14 or 16-year-old girl were found inhumed in a depth 2.5 m without any crypt in the sanctuary bay, buried in a "flower bed" (as written in the work of "Metamorphosis Transylvaniae" by Péter Apor). The manner of the burying as well the decorative Hungarian girl's hairdress come first to light showed that an important finding was found.

<u>Lifting out, packing and transportation of the grave goods</u>

The interior of the church was digged through and through by exploratory trenches and pits, therefore it was impossible to lift out the whole tomb in an only earth block.

An opportunity presented itself, however, for picking up the finding material in two pieces, because the substance was destroyed totally from

the middle of the thigh-bone up to the tibia. In order to take samples from the petals, seeds and sprays, first we lifted out the exposed bone reminders and the false tail of hair. In the next step two wood-fibre plates were pushed carefully under the dark layer marking the bottom of the coffin plank and by the help of these plates the material was brought to the surface.

A shelf divided into two boxes was made and the wrapped pieces imbued with a wetting and disinfecting solution were placed in it. The four open sides of the shelf were covered with wood-fibre plates. The case prepared in this way was packed in corrugated cardboard and transported to the Museum of Applied Arts.

Up to the start of the cleaning the finding was kept in a sterilizator where we could ensure the RH and temperature values developped on the site of uncovering.

Cleaning

The grave goods kept wet till the cleaning were laid on a wooden frame covered with a plastic sieve where the earth soiling of great quantity, the bone reminders and the wood-coffin parts were loosened with a water sprayer and with other tools. In the course of the continuous rinsing the smaller dirts went away through the sieve. The more persistent lime and earth residues could be dissolved by soaking. The shoulder corset and the skirt fragment were lifted into a cleaning bassin together with the sieve and the water was changed until the dirt could roughly be removed from the material got crumpled and stuck together. Then they were laid again on the sieve where the material was carefully spread out. This method was used for cleaning the false tail of thair and the veil. The strips of filet, the cuff and the embroidery fragments stuck to the coffin plank which had a weaker coherence were sewn between two tulles before cleaning.

The removal of the other water soluble soilings was carried out with a mixture of a 10% watery solution of Evatriol (a mixture of the triethanolaminosalt of dodecyl-benzene-sulphonate and laurylalcohol-sulphate) by 4 pH.

The emollition and softening were done with 5% glyceric water.

Disinfection

Against the mouldy growth we used a solution consisting of Sterogenol, alcohol and water (1: 70: 30) on a temperature of 18^{o}C, in the domain of 7 pH. The ability to dissolve the aminoacids of this pH-domain being too high for the silk fibre was hindered by the low temperature.

Having carried out the cleaning, softening and disinfecting of the materials I unpicked the seams of the dress, the velvet strap, the lace from this latter and the trim from the tail of hair and I removed the dirt from the parts covered by them. The undone pieces of the dress were arranged to fibre direction on a glass-plate. The humidity on their surface was soaked up with blotting paper and flannel. In order to prevent the embroidery fragments and filet inlays from being shrunk I fixed them by the help of entomological pins on a Hungarocell sheet covered with blotting paper. In order to smooth out the creases all the pieces were steamed after drying.

A year after the disinfection the false tail of hair had to be softened again with glyceric water. Following the treatment bacterium cultures developped. The infected piece was sprayed with alcoholic water containing salicyl acid (2: 70: 30) in the domain of 4 pH.

After the cleaning the description of the finding complex and the exploration of the formal and technological analogies followed. We determined the dimensions and the basic material of the different pieces, the fabric structure of the textiles, the warp and weft density, the knitting characteristics, the pattern element and the colouring agents of the girl's dress, included the lining, bodice, filet inlay, cuff as well the apron, veil, false tail of hair, girl's headdress and the belt.

Principle and working process of the restoration

Besides the new support materials which played only a static role, I applied no other complements. I did not restore the bodice of supposed cut, nor the apron and the veil, and I fixed only their salvable trimmings.

The embroidery fragments that I was not able temporarily to fit together in form, were processed technically (with the exception of the restoration of the girl's headdress where I did not follow exactly the above-mentioned restoration principle). I supplied the most part of the real pearls, also in the interstices of the lace as well on the calsps, but their place was sure and their supplementing was needed for aesthetic reasons. The place of the complements was precisely fixed in the documentation.

Underlining materials

It is no textile to be got in Hungary which is identical or analogous with the satin of the girl's dress. Therefore I have chosen a material based on a viscose cotton fabric of similar texture.

The velvet strap was strenghtened with viscose stripes, the filet inlays with crape, the cuff with cotton-linen and the veil with pure sill. The sewing thread used for the assembling was a pure silk yarn of $N_m = 200$.

I have painted the viscose materials with direct colouring agents and the silk materials with acidic colouring matters. The fixing of the colouring the viscose satin which was adapted equally for the violet, purplish-brown, brown and tawny colours of the original.

Working process of the restoration of the shoulder-corset

- Cutting the underlining material
- Putting the original material on the supporting one and tacking them together. Fastening the tacked material to the restoration frame. Fixing the two materials one to another with so-called grasping tacks and by the so-called stitching down.
- Taking down the material from the restoration frame
- Cutting the new hemming strap
- Fixing the original hemming strap
- Underlining the velvet ribbon
- Sewing the lace onto the velvet ribbon

Assembling

- Sewing on the hemming straps of the arm-hole and neckline

- Fixing the braids and the lace-work of velvet base
- Lining the shoulder-corset with cotton-linen
- Sewing on 8 new hooks
- Sewing the two sides of the shoulder-corset one to another

A dress-stand upper part was made of 2 cm thick sponge covered with cotton-linen for the storage of the shoulder-corset, moreover a black velvet cover for exhibition purpose.

The restoration of the skirt is still going on.

Working process of the restoration of the bodice fragments

Filet inlays:

- Preparing a pattern card
- Cutting the underlining material
- Putting the original material on the supporting one and tacking them together
- Fixing the two materials by the help of the pattern card
- Taking down the filet inlays from the restoration frame
- Hemming back the support material

Cuff:

- Preparing a pattern card
- Cutting the underlining material and fastening it to the restoration frame
- Copying the pattern
- Fastening the embroidery fragments to the new underlining material
- Taking down the cuff from the restoration frame
- Hemming back the support material
- Indicating the missing parts of the embroidery with

The fragments fastened on one side have been placed for storing on a triplex cardboard covered with cotton-linen.

Working process of the restoration of the veil

- Putting the original material on the supporting one and tacking them together
- Fastening the tacked material to the restoration frame
- Fixing the two materials one to another by so-called stitching down

A support of triplex cardboard is used also for storing the veil.

Working process of the restoration of the tail of hair

- Fixing the disintegrating extremities of the two tails of hair with satin
- Putting back the braid and fixing it into its place

A box, having inside a removable plate of cylindric middle covered with black velvet, was made for its storing which is equally suitable for exhibition purpose, too.

Working process of the restoration of the Hungarian girl's haiddress

Description of the state:

The protuberant parts of the clasp became dented, the enamel was missing in some places, the pearls were destroyed with few exceptions, and the ball-ended wires were bent or broken down. There was a silver sulphide corrosion layer on the silver wire embroidery and the wire had no more metal core in some motifs. The majority of the pearls adorning the spaces of the embroidery has changed into lime and has come to pieces. The velvet ribbon came to light under the circumstances in good condition.

Cleaning:

I removed the great part of the earth soiling in a semihumid state. The pearls to be saved were protected with Paraloid for preventing them from being destroyed during the wet cleaning. After the cleaning I unpicked the clasps from the velvet base. In order to prevent the fine small golden lamellas from coming off the surface I cleaned the corrosion layer on the enamel surface of the clasps mechanically and with great caution. The cobalt blue enamel was well burnt, while the oxide black was weak, illburnt. In order to prevent them from falling out I preserved them with Paraloid.

Temporarily I removed the real pearls from the clasps where these pearls remained. Thereafter the clasps were immersed into a pickle of preheated sulphuric acid so that the coloured copper compounds, the copper oxide, the silver oxide and the silver sulphide could be removed. The treatment was followed by the neutralization, boiling out with distilled water and alcoholic dehydration.

Complementing

For complementing the metal filament embroidery I used a silver wire of adequate size and thickness which was blackened with liver of sulphur (K_2S) so that it could be of similar colour to the original metal threads. The missing 110 real pearls of the embroidery were supplied and the complements were fixed according to the pattern with thin yarns.

The deformed parts of the clasps were flattened out, the ball-ended wires (48) fixing the real pearls were replaced by gilded silver wires. The real pearls were fastened to the clasps according to the original fixing way, then they were sewn onto the velvet base.

Working process of the restoration of the belt

Description of the state:

The whole object was covered with a corrosion layer of basic copper carbonate. As it was a question of gilded silver this could only be explained by the fact that the silver contained a great amount of copper and this was deposited on the surface during the corrosion process taken place in the soil. Two of the linked chain-loops came apart along the soldering.

Cleaning:

The earth soiling having been removed the clearing away of the corrosion layers took place in three phases.

1. The removal of the mechanical stains and mineral deposits succeeded fully with a 10% solution of Komplexon, whereas the CuO, CuS and Cu_2O could be removed only partially.

2. The coloured copper compounds as well the Cu_2O, $AgCl$ and Ag_2S were dissolved with ammoniacal potassium carbonate. A week after the conservation the different corrosion layers appeared again on the object as if it was not treated at all. This was caused by the mineral salts dissolved in the soil and by the treating materials filtered into the interior of the cylinders during the cleaning. In order to remove definitely the corrosion layers forming again and again a deposit on the surface the cylindric elements were bored with a very thin borer. This made possible the cleaning of the inner part.

3. The still existing external and internal coloured compounds were dissolved by a 10% solution of sulphuric acid.

The lessening of the tensions in the material and the removal of the internal dissolved corrosion was achieved by heat-treatment. It was possible to choose this solution because the original amalgamate gilding was of very good quality and thickness. The neutralization was done with a solution of sodium bicarbonate which was repeated five or six times then removed by dissolving this latter with repeatedly changed warm water. The rinsing with distilled water was followed by alcoholic dehydration and drying.

Dating of the Boldva finding

On the basis of the formal and technical shaping of the Boldva dress, the bodice fragments, the supposed cut of the apron and its embroidery fragments as well the trimming of the girl's headdress the making of the dress can be dated at the third quarter of the 16. century. It is the coin dated of 1563 which is a decisive factor for the dating. From the abrasion of the coin the conclusion can be drawn that it had been used for a longer time of five or ten years. As the coin was newly minted in 1577, this year can be considered as an "ante quem" of the dress, respectively of the burial.

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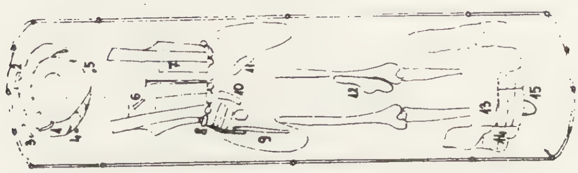
Sketch of the grave

Legends:

1. False tail of hair, underneath a veil
2. Fragment of a chaplet
3. Fragment of a chaplet
4. Embroidery fragment from the border of the veil
5. Trace of the jaw-bone, an eye-tooth
6. Fragment of a flower wrench
7. Shoulder corset with a sewn-on skirt
8. Belt
9. 2 long filet inlays
10. Cuff
11. Cuff
12. Fragment of the skirt
13. Coffin plank with a fragment of the apron on its back
14. Bottom of the skirt with a double-rowed lace trimming
15. Fragment of a leather shoe

o Coffin-nails



81/9/9

THE ROLE OF THE CONSERVATOR AND SCIENTIST IN CONSERVATION RESEARCH

Dinah M. Eastop and Marion H. Lamb

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Textiles

THE ROLE OF THE CONSERVATOR AND SCIENTIST IN CONSERVATION RESEARCH

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ABSTRACT

It is widely recognised that in order to safeguard museum objects a good relationship must exist between curators, conservators and scientists. The relationship between curator and conservator has been considered in the past; the exact nature of the relationship between conservator and scientist needs also to be well defined, otherwise the valuable talents of each may be wasted.

Conservators at the Textile Conservation Centre have had a chemist working with them since 1978, and based on this experience outline three areas where close co-operation is particularly profitable: the teaching of conservation science; the solution of conservation problems; the assessment of industrial research

The role of the conservator, the curator and the scientist in conservation research.

It is widely recognised that in order to safeguard museum objects, a good relationship between Conservators, Curators and Scientists must exist. Lack of resources mean this ideal is very rarely put into practise.

The relationship between Curator and Conservator has been considered (for example Jentina Leene - Problems and Ethics in Textile Conservation Crafts Advisory Committee, Conservation Paper 2 London 1975), but what is the nature of the relationship between conservator and scientist?

It is extremely important that this is clear and well defined, otherwise the valuable resources of conservator and scientist can be wasted.

The Textile Conservation Centre was established to provide courses in textile conservation and a textile conservation service. The Centre is staffed by experienced textile conservators with interests in teaching and research. The need for specialist teaching in textile conservation science and for continuing conservators' researches has led to the Centre employing a chemist as a full time member of its staff since 1978.

Experience over the last three years has shown that close co-operation between conservator and scientist is particularly fruitful in three main areas:

1. The teaching of conservation science

2. The solution of conservation problems

3. The assessment of industrial research

1. The teaching of conservation science naturally plays an important part in the conservation courses at the Textile Conservation Centre. It is necessary that future conservators have an understanding of the chemical, as well as the physical, structure of the materials with which they are dealing.

Most students of textile conservation in Britain have a predominantly arts background - it is, therefore, important that they learn enough of the scientist's terminology to formulate and discuss the questions which form a basis of the relationship between the two, similarly the scientist should learn something of the conservator's terminology.

The conservator's approach is often based on close observation and examination of individual items; the 'feel', 'handle', 'smell' (particularly in the assessment of soiling) and the 'look' are indispensable to a conservator. Such assessment is often difficult to explain or test in any 'scientific' way. It is important that both scientists and conservators are aware of the immense value of such empirical research, particularly as economic restrictions mean that such research will form the bulk of our resources.

The work of the conservator and scientist may also be of direct help to the Curator. Close examination and testing of a textile (for example dye analysis) may provide information about an object, which would help the curator place it in its exact historic or cultural context, and add to a body of knowledge about a particular aspect of textile history or technology.

2. Conservators and scientists also work together in solving conservation problems. Stain removal provides a useful example of profitable co-operation. The conservator and curator will decide whether the stain should be removed. The conservator will then assess the requirements of any stain removing treatment and will discuss with the scientist which chemicals have the desired properties. The conservator will then test and assess the effect of the recommended chemicals before proceeding with the treatment. In this way, curator, conservator and scientist combine their practical expertise.

Such co-operation between conservator and scientist is essential in solving conservation problems. It is important that both conservators and scientists, working closely together, should formulate the questions which form the basis of research projects.

It is surprisingly easy for research tests to be entirely wasted because the right questions were not considered.

3. <u>Industrial product research</u> has long been considered inadequate for museum objects. It is recognized that the nature of old textiles is different from new textiles, and that conservation makes different demands on new products. It is, therefore, valuable that the scientist should

> "assist the conservator in finding new materials and provide scientific information on the composition of the object"
>
> (Leene op.cit.1975)

As an example of such research, resulting from close co-operation between conservator and scientist, the Centre has submitted a second paper entitled "The Prevention of Soil Redeposition in the Cleaning of Historic Textiles".

In order to facilitate this co-operation and understanding, the Textile Conservation Centre has devised a One Year Basic Course in preventive textile conservation which is shared by all students at the Centre, whether their interests are primarily curatorial, scientific or in conservation. This course provides the common vocabulary for all three groups.

Conclusion

The key to a good relationship between conservator, curator and scientist is close co-operation. It must be based on mutual respect. The opportunity for the three specialists to work closely together on a variety of projects for an extended period of time creates a foundation of shared experience. As the assessment of individual conservation projects (which constitute the shared experience) forms the resources of conservation research, the development of a common shared vocabulary is desirable.

The effectiveness of future conservation research will depend on the success of the relationship between conservator, curator and scientist.

STONE

Coordinator : J. Lehmann (Poland)

Assistant coordinator: J. Riederer (FRG)

Members : J.R.J.van Asperen de Boer (Netherlands)
G. Biscontin (Italy)
J.M.Cabrera Garrido (Spain)
V. Fassina (Italy)
N. Gerassimova (USSR)
L. Lazzarini (Italy)
D. Mladinov (Yugoslavia)
R. Ramière (France)
R. Rossi Manaresi (Italy)
T. Stambolov (Netherlands)
E. Szakal (Hungary)
G. Torraca (Italy)
M. Vunjak (Yugoslavia)
E. de Witte (Belgium)
T.V. Yakachvili (USSR)

<u>Programme 1978-1981</u>

1. Critical review of literature - continuation (Stambolov, Van Asperen de Boer).
2. Study on weathering of stone (in general) - continuation (Torraca, Riederer).
3. Weathering of stone in Venice and possibilities of its protection (Fassina, Lazzarini).
4. Assessment of the effectiveness of conservation on the basis of investigations in Bologna (Rossi Manaresi).
5. Study on consolidation of stone in objects of art and history (Gerassimova, Yakachvili, de Witte, Ramière).
6. Study on methods and correctness of conservation of definite objects of art and history (Szakal, Mladinov, Vunjak, Lehmann).
7. Study on protection of stone against humidity and pollution (Biscontin, Cabrera Garrido).

RECENT EXPERIENCE IN CONSERVATION OF STONE OBJECTS. ACTIVITIES AND ACCOMPLISHMENTS OF WORKING GROUPE STONE

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Abstract.

Since 4-th ICOM-Committee for Conservation Triennial Meeting in Venice-1975, the Working Group "Stone" realizes the programme following the recommendation of Directory Board which comprises mainly various problems of the complex conservation and attribution of valuable artistic and historic objects made of stone and stony materials.

Presented set of reports as well as not reported works continued by the members of Working Group comply with in substance adequately requirements of the programme accepted at the 5-th Triennial Meeting of ICOM-Committee for Conservation in Zagreb for the period 1978 - 1981. The problems of examination a. identification, of weathering, of cleaning, consolidation, impregnation a. cleaning, completion a protection against atmospheric humidity, of desirable properties of chemicals used in conservation of stone are discussed.

An annotated literature review as supplement is included. Meetings in the period 1978-1981 at which members of the Working Group "Stone" reported and discussed problems of stone conservation are listed.

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At 5-th Triennial Meeting of ICOM-Committee for Conservation in Zagreb- 1978, the Working Group "Stone" has taken the programme for the period 1978-1981 following the recommendation of Directory Board. It has been realized on the lines laid down at 4-th Triennial Meeting in Venice.

developping and reporting progress in the conservation of stone objects in museums, collections, from excavations , stone objects of art in out-doors exposition as well as in research and examination methods. The reports of the Working Group "Stone" contribute essentially to the world-wide advances in stone conservation. They treat mainly of various aspects in complex conservation and attribution of valuable artistic and historic objects such as desirable characteristics of chemicals used in conservation of stone, identification of kinds and components of stone, investigations on chemical and biological decay of valuable stone objects, protection of stone by means of water repellents a. polymers coatings, cleaning of dirty and stained surface of stone, consolidation of decayed stone, methods of completion and assembling of damaged stone objects, ways of their exposition.

1. Literature review.

The deterioration and conservation of porous buildings materials in monuments is the subject of literature review, supplement 1981, continuation of the survey of the most important papers on stone decay and its treatment elaborated by T. Stambulov a. J.R.J. van Asperen de Boer since 1967. Papers are very carefully chosen out of many articles in periodicals, proceedings and reports of meetings, symposiums, seminars and conferences, listed in the form of references preceded with annotating commentary divided into subjects such as crust formation, moisture content , errosion, quality of stone, cleaning, consolidation a. protection. It has the main virtue of interdisciplinary approach, which is the best way to finding the right way in complex conservation of stone objects.

2. Examination a. diagnosis.

There are in museums various stone objects of different kinds such as works of art and crafts, historic objects a. archaeological finds made of natural a. artificial stones as well as of stonelike materials. The determination of kinds and composition of these objects may be very frequently of conclusive significance upon their autentication and dating.
Two papers of B. Penkala a. E, Bralewska dealing with specific features and comparative analysis of some antique and medieval gypsum mortars have importance to knowledge of ancient and medieval technology and consequently to identification of museums objects of this kind. Accurate determination of kind a. composition of stone is also of importance to choice of appropriate way of treatment and protection.

C. Saiz-Jimenez a. F, Bernier have made ready two papers in weathering of stone by air pollution and lichens. The species and influence of lichens on stone weathering has been studied. Very interesting a. topical is the methodology of study based on scanning electron microscopy, field observation and critical review of recent literature.

The commonly factor of stone weathering in urban and industrial atmospheres are sulfur oxides pollutants. They bring about the formation of gypsum crust on limestone providing the main building stones of the most outstanding monuments of Seville / Spain /. The climatic and environmental conditions in Seville are given.

Scanning electron microscopy, EDAX-analysis of Al, Si, Cl, K and Fe, review of recent literature are given and as conclusion the author states the necessity of restoring Giralda belfry, the Cathedral and the City Hall- the most important monuments of Sevilla- in the near future.

Studies on weathering of stone and especially on dependence between the rate of deterioration and environmental conditions are continued by members of Working Group " Stone". Moreover the results of investigations presented in conferences and meetings, published in various periodical and nonperiodical journals are currently and accurately observed and reviewed.

3. Cleaning of stone.

In conservation of historic a. artistic works in museums a. valuable architectural ornaments the cleaning of stone is of the most importance. It was primarily concerned with the removal of stains. Such cleaning cannot be beyond control. Most museums objects are made of calcareous stones / limestones, marbles, dolomites / sensitive to acidic a. chelating chemicals used for chemical cleaning.

Chemical cleaners and removers of stains for stone objects are applied in form of liquid or paste. In order to enable it to fight against algae and lichens an addition of some fungicide has been used. The most common cleaners a. removers of stains are applied to get out gypsum-soot crusts and iron stains.

The report of M.K. Nikitin a. others deals with removal of copper stains from marble. Marble and bronze are very often combined in museums objects, sculptures, works of art and craft as well as in architectural decorations having quality. They recommend film forming liquid based on the water solution of polyvinyl alcohol, amonia a polymerized sulfoacidic cationite. The method there described has been successfully used in cleaning and conservation of marble with bronze objects.

4. Consolidation.

There are various natural a. synthetic resins applied in the past and nowadays for conservation of stone. The experience has shown that natural and synthetic resins used for conservation of indoor stone objects resulted mainly in good effects. Many attempts to produce resins and to elaborate methods for permanent consolidation of dacayed stone in out of doors exposition took rather poor effect in the past. Nowadays there are some specialized manufactures supplying ready made preparations for consolidation of stone.

Reports of E.P. Melnikova a. M.N. Lebel deal with utilization of polymers for restoration of sculptures in the Sta-

te Hermitage Museum. There are applied various polymers on different purposes not only to consolidate stone sculpture, but also to glue, to varnish, to fill up lacunae, and to reconstruct lacking parts of sculptures, as well as to extract soluble salts from stone.

The desirable characteristics of polymers used in conservation of stone objects in State Hermitage Museum are accurately defined and described. The consolidation is carried out by deep impregnation with gradual strengthened / from 5 to 25% / solution of low viscous polybutylmethacrylate in mixture of alcohol a. xylol. In the case of consolidation of a. sculpture exposed out of doors it is necessary to protect the surface of consolidated stone after treatment with polyethylene wax. Such waxen coating on surface protects efficiently the sculpture for 3 to 4 years.

E. de Witte / with C. Bataillie / reports an other kind of consolidation with synthetic resins. The first part of his investigations on consolidation of stone has been reported at 5-th Triennial Meeting 1978 in Zagreb. The second part just presented is entitled " The consolidation of stone by impregnation with acrylic monomers and deals in details with polimerisation of monomer inside stone catalyzed by means of 1 mol % AIBN /azo-bis-iso-butyronitrile/ or BPO /benzoilperoxide/, with polyester Stratyl A 228 polymerized inside stone, and with acrylic monomer polymerized inside stone by means of gamma irradiation. Investigations have been carried out on samples of 5 kinds of Belgian building stones. In conclusion the authors state that it is possible to consolidate investigated kinds of stone, which is resistant to normal consolidation by means of solutions of polymers, by way of polymerisation of monomers in elevated till 65 - 80°C temperature. In the same way as acrylics it is possible to use polyester.

In presented work the authors have found that it is possible to consolidate kinds of stone very difficult to impregnate with solutions of polymers and to avoid cracks as in the case of consolidation with monomers polymerized inside stone by means of γ - rays.

An other method of consolidation is reported by E.G. Mavroyannakis a. N.R.C. Democritos /Athens-Grece/ in the paper "Treatment of white marble by silanes for conservation purposes".

White marble which is very important material of ancient sculpture and architectural decorations is easily attacked by sulfureous air pollution, transformed into gypsum and undergoing therefore degradation. The presented paper deals with examination of treatment of marble samples / pieces 40 x 30 x 5 mm/ by impregnation with silanes of H and OH type / H = with water repellency effect, OH = without water repellency /, and describes experience with treatment of a number of big objects of ancient marble by impregnation with silanes of H type.

The effect of such treatment consists mainly in filling up porous spaces with silica /silicon dioxide/ and following advantages may be obtained - strengthening of deteriorated

material and protection of the intact material against penetration of air pollution and rain water. The authors found this kind of consolidation as very simple, effective and non trivial method to be without serious limitation from the point of view of the dimensions of the piece to be treated and the repetition of the impregnation.

5. Preservation of stone.

The water repellents for the protection of stone objects is the subject of the paper prepared by P. Frediani a. others from Centro di Studio sulle Cause di Deperimento e Metodi di Conservazione delle Opere d'Arte in Florence . They propose perfluoropolyethers having molecular weight from 6 000 to 7 000 as water repellents to be applied on stone objects.

The perfluoropolyethers Fomblin YR, Y 45, DO and K have been tested on samples / 10 x 10 x 0,6 cm / of the kind of stone Pietra Serena, which is one of important stones in Florentine ancient buildings.

For treatment the liquid perfluoropolyethers are diluted with Algofrene 113 /trichlortrifluorethane/. The efficiency of the treatment was determined by tests of water penetration and contact angle of a small drop of water on the surface of stone.

The perfluoropolyethers are stable and do not react with stone, oxygen, acidic air pollution and humidity. They are permeable for gases and water vapour and do not darken. The results of investigations show as most convenient to use the perfluoropolyether Fomblin YR in 75% solution in Algofrene, sprayed by comresed air sprayer / 3 atm /, onto the surface of stone placed at a distance of 30 cm from the spout. The amount of solution about 80-90 g/m^2.

Further investigations will be continued to verify the durability of treatment by natural and accelerated ageing.

6. Conferences, symposia, meetings.

In October 1979 in Venice 3-rd International Congress on the Deterioration and Preservation of Stone took place under auspices of UNESCO and Universita degli Studi di Venezia. Members of Working Group "Stone" of the ICOM-Committee for Conservation- G. Biscontin, V. Fassina a. L. Lazzarini have presented reports on studies an protection of stone against humidity, air pollution and weathering under conditions in Venice.

In November 1979 an International Symposium on research in conservation of archaeological objects has been organized in Łódź, under auspices of ICOM- Polish National Committee, Working Group "Conservation". J. Lehmann has reported recent advances in examination and conservation of stone objects.

In April 1980 an International Meeting on Conservation has been organised by ICOM-National Committee of German Democratic Republic in Berlin. H. Materna has reported aspects of stone objects conservation in G.D.R.

In February 1981 a Conference on Conservation of Historic Stone Buildings and Monuments took place in Washington . This conference was sponsored by the U.S. National Research Council and National Academy of Sciences in frames of various projects undertaken under the CCMS Pilot Study - The Conservation of Stone Monuments. Although conservation of historic buildings is rather the subject of studies for ICOMOS- some aspects are of interest for Working Group " Stone " of the ICOM- Committee for Conservation, e.g. problems in deterioration of stone, cleaning a. surface repair, polymers as consolidating a. protective materials, evaluation of stone preservatives, climatic a. microcli - matic conditions. Very interesting are works and studies of New York University- Conservation Center.

3-rd International Seminar on Conservation has been organized in July 1981 by Hungarian Academy of Sciences and Hungarian Institute of Conservation and Methodology of Museums in Budapest for conservators a. restorers. This conference took place in Vesprem and problems of practical stone conservation have been reported and discussed.

A very important symposium on conservation of stone is prepared and will take place in Bologna in October 1981. The symposium is organized under the auspices of UNESCO by Centro Conservazione Sculture all Aperto in collaboration with ICROM, ICOM a. ICOMOS.

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The Working Group " Stone " of the ICOM- Committee for Conservation presents at 6-th Triennial Meeting reports supplemented with informations from other pertinent sources.
It is necessary to survey the extent of the problem including the chemical, physical a. biological processes, the methods of protection of objects threatened by the effect of air pollution and humidity, weathering and other man - made and natural phenomena, the effectiveness and correctitude of preservation a. restoration methods.
There is a need for new approaches to the conservation of historic a. artistic stone works. The problem involves many scientific, humanistic, engineering a. artistic disci - plines.
Analysis a. discussion of reports and informations at the Session of the Group, conclusions and recommendations will improve the programme for the next triennial working period 1981 - 1984.

81/10/1

THE DETERIORATION AND CONSERVATION OF POROUS BUILDING MATERIALS IN MONUMENTS. A LITERATURE REVIEW. SUPPLEMENT 1981

T.Stambolov and J.R.J. van Asperen de Boer

ICOM Committee for Conservation
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Working Group: Stone

THE DETERIORATION AND CONSERVATION OF POROUS BUILDING MATERIALS IN MONUMENTS. A REVIEW OF THE LITERATURE. SUPPLEMENT 1981

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1. Introduction[+]

Many advances in the conservation of stone were first reported at specialized conferences. Mamillan (32) has listed 12 meetings between 1966 and 1978.
Since the previous Supplementto this literature review was written early in 1978 (54) further meetings on the subject took place of which were published proceedings (1, 2, 58). Papers related to the preservation of porous building materials in monuments were also presented at the IIC Vienna 1980 Congress (22). The Austrian IIC Group devoted the 1979 and 1980 issues of its annual publication to problems in the conservation of stone and monuments; they contain numerous useful contributions in German (21).

2. Weathering by moisture and salts

2.1. General

An important monograph on stone weathering and conservation was published in 1978 (74). The editor Professor Winkler contributed also a short literature review to his publication on stone weathering (75); K.L.Gauri wrote a brief review of the literature on the conservation of stone (16).
According to a recent reassessment of the breakdown of porous stones (20) the moisture that enters the pores is considered, all by itself, to be the major cause of damage. This view is based on the knowledge that water contained in porous structures is held there mainly in adsorbed state, thereby damaging these porous structures.

The model outlined by the author shows that water, upon entering the pores, structures itself in an orderly manner along the walls of the pores. The degree of structuring and the

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[+]The decimal headings refer to the corresponding chapters of the original review (T. Stambolov, J.R.J. van Asperen de Boer, The deterioration and conservation of porous building materials in monuments. A review of the literature. International Centre for Conservation, 2nd ed. Rome 1976).

number of molecular layers of water so structured depend on the kind of surface and the polarity of the liquid (in this case water) which wets it. With respect to water clay surfaces are more sorptive (57) than carbonate surfaces. Besides the structuring of water is akin to crystallization.
If the pore is small enough, the structured, rigid water - so called because of its crystalline arrangement - fills the entire available volume of the pore and can begin to exert pressure. The action is similar to that of ice formation, and explains the increase in the transverse wave velocity, volume increase and pressure increase measured in wet stone. This also elucidates why by alternately heating and cooling (between 25°C and 70°C) porous stones saturated in highly polar organic liquids as formamide, stone decay resembles frost damage although no formation of ice can be detected. But even if freezing of formamide would occur, it cannot possibly account for the damage inflicted to the stone, because the freezing of formamide, unlike water, is not accompanied by a volume increase (see also our Literature Review 1976, section 4.2 the effect of freezing nitrobenzene).

Wetting and drying of stone, the pores of which are filled with rigid water, have thus an effect similar to freezing and thawing. The stone is with the same rhythm alternately stressed by the adsorbed water, and unstressed when the water evaporates.

Likewise temperature changes affect the number of layers of water structured by the surface forces. The pressure thereby is comparable to the one developed by wetting and drying. The highest degree of structuring due to thermal influence appears to take place in the 20°C to 30°C range. In fact, water adsorbed at 20°C becomes in part bulk or freezable water at -16°C.
Because of the stresses set up by the adsorped water the stone fails in tension by fatigue due to the combination of sorption - desorption and temperature changes. Winkler (74) sustains this view by stating that when the capillaries are filled with water, damage is to be expected during the process of heating, because in such circumstances water expands more than the stone substance. As a matter of fact, a diurnal temperature difference of 40°C near the surface of a masonry wall can develop about 260 atm pressure by the expansion of the entrapped moisture.

2.2. Crust formation

All harmful salts found in the crust on building stones, mortars and cement containing masonry are discussed at length by Weber (62). In an exhaustive classification these salts are grouped under the headings: sulphates, nitrates, chlorides and carbonates and their respective role in the corrosion process as regards their property to either form a hydrated deposit or water-free one is explained intelligibly. A salt, it appears (62, 14), is deleterious to the crust if it is capable of being more soluble in water than the stone material itself; if it is hygroscopic; and if it can take in its crystals water becoming thus a hydrated salt. The damaging action of sodium sulphate in particular, should be stressed in this context as it i thought to equal the frost damage. It is because of the capability of its crystals

to exert a force similar to that exerted by the growth of ice crystals, that sodium sulphate is used in the ASTMC 88 1973 test, to judge the resistance of a stone sample to deterioration under freeze - thaw conditions (17).

In addition to dealing with the same salt subject - and with a similar clarity - Koller (26) gives attention to the mechanisms of crust collapse due to the crystallization of salts in the porous network of both crust and the stone underneath.

It is moreover pointed out (23) that the calcareous stones undergo a singular disintegration owing to the complexities that exist whenever water that contains carbon dioxide - and this is the most common condition in nature - wets or perculates in a calcareous stone. The system of interactions resulting from such a contact holds together undissociated carbonic acid, H_2CO_3, its two stages of dissociation: H^+; HCO_3^{--}; $CO_3^{=}$, and limestone $CaCO_3$. Below pH 5, carbonic acid, H_2CO_3 dominates; from pH6 to pH10, bicarbonate, HCO_3^- dominates; and above pH 10, carbonate, $CO_3^{=}$, dominates. In the naturally typical range of pH 7 to pH 9 water that wets stones or perculates into them, dissolves limestone mainly as calcium bicarbonate, $Ca(HCO_3)_2$.

With decrease in temperature and increase in partial pressure of carbon dioxide, the solubility of carbon dioxide in water is increased and as a consequence more limestone is dissolved. For example, the solubility of limestone in mg per kg, in pure water exposed to 0.033% of carbon dioxide is 96 at 0^oC; 59 at 20^oC; and 49 at 29^oC. In winter time therefore, the dissolution of limestone by carbon dioxide containing water is markedly greater.

Prolonged observation of marble statues at the Acropolis, and especially of the gypsum crust on them, has led to the conclusion that the carving details originally cut in marble, remain unchanged in the gypsum layer, which, due to air pollution will in time unavoidably cover all exposed calcareous matter. The preservation of relief by the gypsum crust is of but relative meaning, as gypsum is dissolved by rain and with it, of course, the carving (52). Gypsum areas protected from rain water - and they might be very extensive as actually was the case with the statue of a Caryatid, discussed by the author, are good conveyers of the profile of sculpted marble.

In addition, crusts on cement and cement containing materials, may be permiated by metal soaps, if vegetable or animal oils, fatty matter and resins have, at any time, been in contact with them(24). The organic metal compounds resulting from this interaction are as a rule softer that the inorganic salts, and therefore their presence would in time weaken the crust and eventually assist in its errosion. Naturally, the above considerations are applicable to all other calcareous materials, provided oils, fats and resins are present - this being explained by the fact that calcium salts are rather easily transformed into soaps.

2.3.3. Bricks

In a series of contributions (1) presented to the International Meeting on the Bricks of Venice, an outstanding clarification is given as to all possible aspects concerning bricks and

masonry. Manufacture, deterioration, conservation, testing and investigation are all commented upon.

Mamillan (33) surveyed e.g. various methods of testing the properties and the deterioration of brick structures in general.
In a comprehensive glossary Torraca (57) explains even quite complex phenomena in a plain manner and with minimum use of scientific jargon, so that the conservationists, unobstructed by unfamiliar terminology, could more fully recognize the practical implications of appropriate facts and technology needed and used in safeguarding brick structures.

Of similar merit is also the paper by Lewin and Charola (31) for its thorough dealing with hydration of excess lime in bricks and in consequence the possible bursting of such bricks; the effects of pollutants and salts on the rate of brick deterioration; and the theory and chemistry of impregnating bricks with reliable consolidants.

Erfurth and Tenge (14) present a paper in which they establish the rate of damage due to crystallization of soluble salts. After that they propose relevant counter measures, and, being aware of the various environmental circumstances in which conservation might have to take place, they also critically evaluate these measures.

The interaction between materials of different nature is examined by Padoan (37) who is particularly concerned with cases when bricks happen to be in contact with marble - a harmful but quite frequent and abundant combination in Venice. The author suggests several remedies.

3. Moisture in porous building materials

The IIC Vienna 1980 Congress (22) clearly stimulated the publication of investigations into microclimate inside monuments. The relation between hygric and thermal conditions and deterioration was studied in a number of cases.
Accardo and Camuffo (3) measured distributions of the air temperature and humidity inside the Scrovegni Chapel in Padua. They also mapped the radiant emittance of the walls - covered with the Giotto frescoes - at various times using AGA Thermovision equipment (indium antimonide detector cooled by liquid nitrogen with an infrared responsivity between 2 and 5.6 microns resolution 0.2 °C). Ventilation and the transport and diffusion of air pollutants within the chapel were also studied with non-destructive methods.
Seracini *et al*. published some examples of non-destructive examination with thermography of monuments in Florence elucidating in this way the building history (51).
Stefanaggi and Callede (55) reported about experiments to relate moisture distributions in walls with differences in emittance using thermographic methods.
The influence of wind, water, rain and fog on the distribution or air pollutants has been investigated in Venice by Frassetto (15).

Bettembourg (8) studied the internal temperature and humidity in the church of Saint Père in Chartres with a particular view of assessing the condensation on the stained glass windows. Such studies are obviously equally useful for an understanding

of the deterioration of the porous materials in the building.

Wencil Brown et al. (67) reviewed the deterioration and conservation of adobe structures with particular reference to Arizona and New Mexico. Long-term preservation depends largely on the possibilities of keeping the structures dry. Particle size distribution in adobe is found to be important in assessing weathering characteristics and chances of consolidation (68)

3.2.1. Diffusion of water vapour

Wittmann (76) discussed some physical properties of natural porous stones and considered the influence of salts on capillary condensation. Data on hydration pressures of various reactions of $CaSO_4$, $NaCO_3$ and $MgSO_4$ at 100% and 70% RH and pressures of crystallization at different saturation levels are given.

4.2. Frost damage

A graphic explication of the effects of freezing water inside porous stone or other similar matter, stresses the condition that trouble would occur only when the pores are filled with water for more than 91% (26). In that case the extension caused by the formation of ice is capable of damaging the imbibed enclosures. Such, almost complete imbibition is, according to the author, only encountered in the rare instances when prior to use, the building stone units are thoroughly waterlogged. Once fixed in the masonry, such stones cannot dry and consequently would be vulnerable to pressure deriving from freezing water. This view is supported by the observation that if frost damage should occur at all, it would do so in excessively wet stones, and usually during the first frost period, following completion of the construction work.

In normal circumstances the stones in the masonry cannot be imbibed entirely, and therefore are, on the whole, unyielding to frost damage. Of course, extraordinary sources of moisture like prolonged thawing water or rising ground water are often capable of saturating certain parts of a building to the required extent of above 91%, and thus render them vulnerable to frost.

The various salts dissolved in the water that fills up the pores, influence the amount of frost damage (62). As the concentration of the salts in such a solution is greatest in the vicinity of the surface of the stone, and as a consequence of it the freezing point of the solution there is largely depressed, the moisture held deep inside the stone freezes first. However when the temperature outside decreases sufficiently the moisture in the uppermost layer of the stone freezes in a like manner. Yet under this ice there is still an interstitial layer of fluid sandwiched between the already formed lower and upper ice lences. It is the last to freeze and because of the two-sided enclosing, the expansion developed by its convertion to solid ice, would force the surface layer of the stone to flake off.

Moreover, organic and inorganic compounds alike, seem to enhance the frost damage (61). For instance, amounts of as low as 0.1 volume % of glycol in water lead to considerable increase of stone destruction by freezing, while concentrations

of glycol in the range of 0.5 to 5 volume % can cause four times as much frost damage.

Chemical substances as urea, aldehyde, ammonia and rock salt - all in use as thawing agents - have a promoting effect on the frost damage in stone. This effect resembles that of glycol, whereas 0.5% solution of sulphuric acid (generated by air pollution, for example) has notably lower influence on the frost damage, as compared to the above mentioned substances.

4.4. Dust pollution

Srámek in an imaginative approach to the determination of the origin of gypsum crusts on calcareous stones such as marble and limestone encountered in the city of Prague, used the measurement of the ratio of the two most abundant sulphur isotopes, i.e., $^{34}S/^{32}S$. The knowledge that in the biogenesis of sulphur (during which sulphur is produced through the reduction of sulphates as low temperature by the action of anaerobic, sulphur-reducing microorganisms) the amount of the isotope ^{34}S in the ratio $^{34}S/^{32}S$ is markedly diminished, serves as detector which specifies the nature of the sulphates participating in crusts. The measurements are expressed in delta units, $\delta^{34}S$ (‰),and it is stated that the value of the delta for sulphate-material resulting from biogenesis can reach as low values as -20‰. Samples taken from: pure gypsum; crusts from limestone surfaces; marble surfaces; rain water; and sandstone surfaces were run through a M86 isotope mass spectrometer in order to determine this ratio. Study of the infraredspectra of the samples, showed that the value of $\delta^{34}S$ varied in the range $+3\pm0.2$‰. This excludes sulphates derived from biogenesis, and justifies the conclusion of the author that the main source of sulphate in the crust on marble is the sulphur dioxide from polluted air (53).

For the oxidation of sulphur dioxide to sulphur trioxide, which, with water, delivers the corrosive sulphuric acid, traces of metals such as iron, manganese and cobalt are of decisive significance. They function in the oxidative reaction as catalysts (10). Other models for the conversion of sulphur dioxide to sulphur trioxide comprise the photochemical oxidation in water drops and the indirect, but complex, photochemical oxidation in which sulphur dioxide, ozon,nitrogen oxide and reactive hydrocarbons are involved. Absence of one of these substances arrests the oxidative interaction and is, for the purpose of air pollution control, of some merit, as reduction of the emission of nitrogen oxide and reactive hydrocarbons would be the reason that sulphur dioxide remains almost unchanged. Which means that in such an environment, provided only moisture were available, no corrosive sulphuric acid aerosols could be formed (9).

One additional aspect of the oxidation of sulphur dioxide is the pH of the humid air. The sulphur trioxide resulting from the oxidation, forms with water sulphuric acid, but at pH values below 2, the formation of acid stops. If in the air, a certain amount of naturally formed ammonia is also present, it will neutralize the sofar produced acid and will after that exist as ammonium sulphate. The reaction producing sulphuric acid is thus unblocked and proceeds until all of the available sulphur trioxide is exhausted. Hence

the importance of ammonia in the development of detrimental sulphuric acid aerosols (10, 9).

5.1. Remedial measures against moisture

Although a number of concise introductions and surveys have been published on combating moisture in monuments (35, 49, 64) there is little news in this field. Schimmelwitz (49) attempted to eliminate unsuitable methods by measuring moisture distributions before and after the "cure". He stressed the importance of the availability of measured data on the condition of the monument before and after treatment.
Tenge (56) reviewing the applicability of injecting methods to impede rising damp in Venetian brick structures was sceptical of results because of the high salt concentrations present; he considered preliminary conversion of soluble salts into insoluble compounds necessary.

Prandstetter (41) recommended to repair the top of solid brick walls in ruins, etc. by inserting an oblique layer of epoxy-mortar. His article contains many other practical hints.

5.1.3. Drying by means of heating

The influence of heating on the deterioration of mural paintings in Sweden was discussed by Nisbeth (36) who showed that before the introduction of recent heating systems murals had remained virtually unchanged over centuries. Decay can be rapid due to increased evaporation and efflorenscence.
Beck and Koller (7) in an excellent review of heating within monuments in Austria describe briefly a number of historic heating devices. They then present many examples of heating systems actually employed and their merits. One of their conclusions - based on many measurements of temperatures and humidities within the buildings - is that constant floor heating systems minimize damage. Heating in winter not exceeding 10 °C at RH values above 50-60% may be assumed to be harmless, but the critical temperature is 12 °C!
Koller et al.(27) also reported on the climate and environment of the abbey church at Melk.

5.2.1. Cleaning with pure water

A marble carved seat was desalinated by placing it in a basin of PVC-sheets. The basin was fitted with an external circulation system consisting of a pump, a filter, a de-ionisation cartridge and a cartridge with crushed marble. The basin was also provided with a thermostatic heating device, and another device that maintained a constant stream of air bubbles (the air needed for the bubbles was passed through a bottle of sodium hydroxide solution, which guaranteed the avoidance of attack on the marble by water contaminated with carbon dioxide from the air (23). The crushed marble was needed to prevent another kind of attack on the marble - the attack that is caused by water of less than the optimum hardness. In the course of three weeks the basin was gradually filled with water (a hasty filling of the basin would have led to the entrapment of air in the capillaries of the marble, obstructing thus the extraction of salts). After 60 days of treatment the salt content was reduced to 50 mgr/lt, at which point the desalination was considered to be adequate (12).

5.2.6. Chemical cleaning

Several articles deal systematically with assorted preparations employed currently in the cleaning of stone (63, 47, 42, 4). Restorers involved in the removal of dirt, stains, crust and efflorescence, covering stone surfaces, will find in these papers many helpful tips as to how to approach and solve problems relating to the appearance of such surfaces.

The methods to soften and remove gypsum crusts, in particular, deserve mentioning here. In order to dislodge gypsum, the crust that contains it is covered with a paste consisting of: 50 g of urea, 20 ml of glycerol, 1 l. of water and enough of sepiolite or attapulgite to make a paste (18).

In a critical lecture concerning the ethics, foolishness and relevancy with regard to the practice of cleaning Crèvecoeur (11) cites three occasions in which gypsum crusts developed respectively on glazed tiles; on a mural painting embedded in gypsum; and on a sand-limestone sculpture, were effectively removed by the use of alkaline KOMPLEXON paste (See Supplement 1978, Chvatal's paste of the sodium salt of etylenediaminetetraacetic acid).

Gravely polluted limestone sculptures, may also be well cleaned by the so-called Baker's process. It involves the application of slaked lime paste as a kind of poultice around the sculpture, the thickness of which is about 1.5 inch. The poultice is kept in place by dampened hessian. After several weeks it is scraped off with much of the dirt and soluble salts coming off with it as well (34).

5.3. Consolidation and protection

Selected methods and procedures for testing agreed by the RILEM 25 P.E.M. Group have been published in both English and French and are recommended to measure the deterioration of stone and to assess the effectiveness of methods of treatment (59).

A review article (65) and a book (25) compile all significant facts that characterize the properties and relevancy of application, of the substances which are used on porous stone materials in need of impregnation and consolidation.

Deteriorating sandstone objects can be consolidated according to a treatment described in a Dutch patent(38). The chemicals employed in this consolidating procedure are complex compounds as well as double salts, which, as a rule, are more soluble in water, than their respective components taken apart, and it is this increased solubility that guarantees a deep penetration of a solution of such complexes into the pores. Alkaline earth metal salts, aluminium salts and heavy metal salts of either formic or acetic acid, are combined in order to prepare the impregnating formulation. An example of it is the following recipe: 300 ml of 25% acetic acid is diluted by adding 100 ml of distilled water. To the diluted acid are added successively 20 g of aluminium hydroxyacetate, 13 g of magnesium oxide and 40 g of calcium carbonate. All chemicals are heated until dissolved completely. The solution obtained thus has a pH value of 4.4. Afterwards 1 g of copper formiate - which dis-

solves under some stirring - is added to it. The fluid is now ready for use. It can be applied on the stone by brushing, by a sponge or by a spray gun. After treatment the sandstone is left to dry. The carbon dioxide from the ambient air disintegrates the complexes and precipitates their components in the stone as deposite of dolomite stone, $CaMg(CO_3)_2$. The solidification of the solution containing the above mentioned complexes may be speeded up by impregnating the already dried sandstone with a mixture of 10% by weight of 35% of hydrogen peroxide and 90% by weight of isopropyl alcohol. It is claimed that this mixture both dehydrates the deposited mineral consolidant and changes the pH value in the stone in a manner favorable as to the consistency of the consolidant.

5.3.4. Silicone esters

Critical evaluations of the merit of silicone ester as stone consolidant are attempted in various studies (69, 70, 66, 48, 19, 43, 29, 5, 34). From these studies only the statements are abstracted which are complementary to the original Literature Review 1972 and the preceding two Supplements of 1975 and 1978.

- The most common use of silicone ester (alkyltrimetoxysilane, Wacker BS 20) is to impregnate and stabilize deteriorating alkaline materials like: limestone, dolomite, marble, cement, sand-limestone, sandstone ceramics frescoes - materials that besids have to be damp (but not waterlogged) prior to treatment. For materials of inferior absorbtion capacity, the silicone ester emerges sofar as the only effective consolidant. One indispensible requirement in all cases is that for optimum stabilisation of the stone, prior to treatment with silicone ester, the material must be damp. Moreover, the alkalinity of the material is of great importance, because it acts as a catalyst (46) of the reaction, during which the silicone ester undergoes hydrolysis, looses alcohol and polymerizes as a siloxane gel. The curing of silicone ester proceeds according to the equation (34):

  $$(1)\quad -\overset{|}{\underset{|}{Si}}-OR + H_2O \longrightarrow -\overset{|}{\underset{|}{Si}}-OH + ROH$$

  $$(2)\quad -\overset{|}{\underset{|}{Si}}-OH + -\overset{|}{\underset{|}{Si}}-OR' \longrightarrow -\overset{|}{\underset{|}{Si}}-O-\overset{|}{\underset{|}{Si}}- + R'OH$$

  $$[R= CH_3;\ C_2H_5;\ R'=H;\ CH_3;\ C_2H_5]$$

- The most favorable temperature in treating stone and related materials with silicone ester, lie between 15° and 25° C (48), but according to still another consultant (66) the best results with silicone ester are achieved at temperatures between 5° and 20°C. Direct sunlight should be avoided during application as it tends to elevate the temperature above the optimum temperature traject. This invariably leads to premature evaporation of the solvents with which the silicone ester is diluted for the purpose of a deep penetration into the stone. Such untimely separation interferes with the capacity of silicone ester to permeate the stone and is often responsible for the disappointing results of consolidation practices.

- In the view of a manufacture (5) the silicone ester should be used as a 10% solution in alcohols. But again, another experts contest this (66,46) and insist that the content of silicone ester that guarantees a reliable stone consolidation should not be less than 60% - the best dilutants being alcohols and ketones. From a 75% solution of silicone ester precipitates, due to curing, about 300 g silicagel per kg silicone ester solution. Hence it is understandable that contents of less than 60% of silicone ester leads to unsatisfactory impregnation results. Above 75% (in some products the amount is as large as 85% (13) the silicone ester solution becomes unfeasible as a trade product and is not manufactured as such.

- Especially with respect to marble, the nature of the catalyst needed for curing of the silicone ester is of importance, because if it is an acid, the marble will certainly undergo etching. It is therefore required, that prior to use the composition of the stone consolidants, type of silicone ester and catalyst are known. Many catalysts have been proposed (43) and some of them are already included in the commercially available products (34, 46). Normally the one-component silicone ester stone consolidant contain as a catalyst a neutral substance, i.e., one of the metal soaps, preferably lead naphthanate (66, 43).

- Decisive requirement for a successful consolidation is a long contact between porous stone material and silicone ester. This means that for a good effect the silicone ester should be applied repetitively 10 to 15 times, between intervals of 5 to 15 min. For good measure this treatment should be carried out at least one more time after 2 or 3 weeks. Impregnation may be carried on either by immersion of the stone in silicone ester, or by brushing or spraying it with consolidant (66, 48).

- The depth of penetration is claimed to extend from 5 to 10 cm (66, 48). But this assertion is not yet considered to be a generally accepted fact. Actually, the results obtained from tests on regional limestone and sandstone types in some countries, disagree with it. In Czechoslovakian limestone types the depth of penetration after 28 hours of impregnation was less than 5 mm (19), whereas in German varieties of sandstone, i.e., red Miltenberger Main sandstone and green Main sandstone, the attained depth of penetration was respectively 2 mm and 3 mm (69, 70).Riederer (45) however disagrees with this pessimistic assessment and points out that the depth of penetration of silicone ester is "incredibly high; even in sandstone or in bricks a depth of 5 cm is attained, and in porous or decayed stones the penetration is still deeper." From the survey of Riederer appears, moreover, that stone objects which were treated with silicone ester about 15 years ago, are still intact, well preserved and do not show any noticeable damage, that could be attributed to the silicone ester treatment. Unfortunately, the high cost of silicone ester confines its use mostly to statues and ornaments of

considerable value.

- o Compared to other consolidants, in particular synthetic resins, silicone ester is a superior consolidant in that it diminishes the effect of both drastic temperature changes and frost on the treated stone (19).

- o Silicone ester is a toxic chemical. It reacts vigorously with strong acids and bases. It is absorbed by the human body through inhalation and ingestion. Silicone ester may cause irritation of eyes and respiratory tract and may inflict damage to the kidneys. In working with silicone ester preventive measures should be taken:
  1. No fire, no sparking, no smoking are allowed during work.
  2. Adequate ventilation or chemical cartridge respirator must be available and employed.
  3. Chemical goggles and rubber gloves are obligatory (39, 6).

5.3.5. Silicones

Several recent publications are available about synthesis, properties and use of silicones as protective agents against deterioration of stone materials (5, 48, 44, 60, 40).

The decisive factor to keep in mind when a choice is to be made from various brands of silicones, is their constancy with regard to alkaline reacting materials. Alkalinity, it should be mentioned here, is a property that is inherent in most stone materials. The degree of standfastedness of the silicones in alkaline environment is determined by the shape of the alkyl groups attached to the siloxane chain, and this characteristic is not disclosed by all manufacturers (5). In the steadfastedness with respect to alkalinity must then be sought the understanding of the peculiar phenomenon why awhile all available brands of silicones claim the same efficacy, in practice, many of them perform so poorly.

5.3.6. Synthetic monomers

Disintegrating stone objects are hardened and strengthened by impregnating them with methyl methacrylate in an autoclave under an approximate pressure of 10 to 15 atm (69,70, 71, 72). During the treatment the objects are filled thoroughly with monomer, which afterwards solidifies as polymethylmethacrylate (plexiglass).
Plexiglass is, however, not as stable a synthetic resin as a stone conservator would wish it to be. The shortcomings of plexiglass are disclosed in a display of fine cracks on a plexiglass household spoon (73). The spoon (after 10 years of kitchen use and with a possible ultimate life of about 15 years) was used for stirring instant coffee, powdered lemonade and warm chocolate, with a maximum temperature exposure of about 60°C. This temperature resembles the thermal conditions in a natural site, where a methylmethacrylate impregnated stone is alternately exposed to sunlight. It is true that ultraviolet radiation cracks and weathers plexiglass. But also without light, during continuous storage of a plexiglass spoon in a dark kitchen drawer (away from U.V. Radiation) a similar cracking pattern becomes visible. Such impairment is

attributed to the contraction caused by "aging", that is, the incipient crystallization of the otherwise amorphous plexiglass. It is presumed that the same processes are bound to occur on stone impregnated with plexiglass.

5.3.7. Synthetic polymers

Synthetic polymers suitable for the conservation of stone materials , with emphases on their usefulness for particular purposes and their likely failure in the case of indiscriminate application are discussed in several publications (47, 50). The drawback, all these polymers have in common, is the insufficient depth of permeation. Only the silicone resins are an exception to this observation. Hence a 25% solution of silicone resin in organic solvent is proposed as an effective consolidant (50).

A considerable attention is also given to the use of epoxy resins in the field of stone conservation (28, 19). But the main disadvantage of the epoxy resins is still considered to be their tendency to turn yellow, and besides, to become brittle under aging (70, 28). To these well known shortcomings is now added a peculiarly damaging effect of the epoxy resins on treated stones - namely that at extreme temperature changes, occurring in natural circumstances, the epoxy resins impart to the stone 5 times as much shearing stress as it is measured in untreated stone (19).

Alabaster, limestone, sandstone and marble are, according to the report by Larson (30), materials which can successfully be impregnated with an acrylic-silane mixture, that bears the trademark of Racanello E 0057 (Ard. F.lli Raccanello S.P.A. Industria Venici e Smalti, Padua, Italy).

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THE CONSOLIDATION OF STONE BY IMPREGNATION WITH ACRYLIC MONOMERS

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Working Group: Stone

THE CONSOLIDATION OF STONE BY IMPREGNATION WITH ACRYLIC MONOMERS

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SUMMARY

The consolidation of 5 building materials is investigated: Tuff of Maastricht, Avesnes, Euville, Balegem, and Gobertange.
As well smaller as larger samples can be consolidated by impregnation with a 50/50 mixture of methyl acrylate / ethyl methacrylate at which 1 mol % initiator is added. The temperature should be at least 65°C, for larger samples 80°C.

Good results can also be obtained by radical polymerization of polyesters. Experiments with gamma irradiation showed that in many cases cracks are obtained and that the best way to avoid these is by adding initiators to the monomer mixture and by working at high dose rates.

1. Introduction

In previous papers (1,2,3) we reported the consolidation of tuff of Maastricht by impregnation with a mixture of methyl methacrylate and ethyl acrylate, followed by polymerization at elevated temperature. The results showed that the following experimental conditions can be used:
- impregnation under vacuum with a 50/50 mixture of methyl methacrylate/ethyl acrylate, at which 1 mol % azo-bis-iso-butyronitrile (AIBN) is added.
- polymerization by heating the impregnated stone at a temperature of at least 65°C.

Polymerizations initiated by gamma irradiation showed the appearence of cracks in the stone.

In this work the experiments were enlarged to 5 different kinds of materials: Tuff, Balegem, Euville, Avesnes and Gobertange.
Experimental conditions were tested out to obtain good consolidations of these materials by using radical and γ -polymerization. Also polyester was used to carry out consolidation, but in stead of gamma irradiation a radical initiation was used.

2. Results and Discussion

2.1 Radical Polymerizations

The impregnations were carried out as described before, but in stead of using methyl methacrylate and methyl acrylate as impregnating agent, a 50/50 mixture of ethyl methacrylate and methyl acrylate was used. We changed over to this monomer mixture as it was found meanwhile (4) that this are the monomers used to prepare Paraloid B 72, a well known product and one of the most stable polymers used in conservation (5). As initiator, as well AIBN as benzoilperoxide (BPO) can be used. As shown in figure 1, the reaction will be somewhat faster when using AIBN: the reaction takes place after 1 hour, with BPO as initiator only after 1 h 20'.
The five kinds of stone were treated in the same way and as can be seen from the results in table 1 the degree of impregnation is proportional to the porosity of the non treated stone.

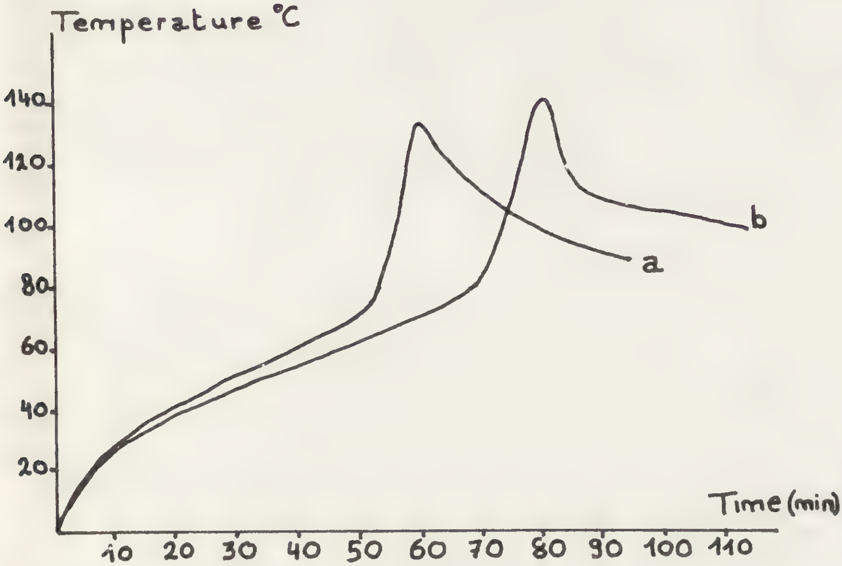

Fig.1: Temperature in Tuff duering polymerization.
a: AIBN
b: BPO

All polymerizations resulted in a good consolidation. Cracks were never observed. This proves that the experimental conditions, as they were defined for tuff, are also suitable for the 4 other materials.

	Ws	Wm	Wm/Ws	Wp/Ws	P(%)
Tuff	170.3	39.7	0.35	0.25	50
Avesnes	172	43.7	0.25	0.23	41.2
Euville	339	28.9	0.085	0.083	19.5
Balegem	326.1	17.4	0.053	0.046	11.7
Gobertange	298	16	0.054	0.051	11.6

Table 1 Consolidation of 5 building materials
Ws : Weight of stone in grams
Wm : Weight of absorbed monomer
Wp : Weight of polymer in the sample
P : Porosity of the non treated sample.

In order to have an idea of the changes in properties, due to the impregnation, the porosity and the hardness of the different samples were determined.

2.2 Porosity

The porosity, in volume percent, was measured by weighting the sample dry (Wd) and impregnated with water (Ww). Subsequently the stone is weighted under water in order to determine the exact volume of the stone (Wo). The porosity can be calculated from these three values. From the results in tabel 2 follows that the porosity decreases in all cases. The differences which are observed for the treated samples are caused by variations in the amount of polymer in the stone. Depending on the Wp/Ws ratio a range of porosities can be obtained.

2.3 Hardness:

The hardness was measured as described in our earlier work. The weight of the widia knife was adopted to the hardness of the stone on order to obtain a scratch of a good measurable widthness. All experiments were carried out in five fold and the results in table 2 are average values.
Except for Euville, the hardness of the four other stones is comparable after treatment. This means that the softer the original material is, the largest the increase in hardness will be.

	P (%)		Hardness		
	Untreated	treated	Weight on Knife (g)	Width of scratch (mm)	
Tuff	50	17.5-25.3	500	1.29	0.25
Avesnes	41.2	5-15	700	0.78	0.22
Euville	19.5	3.2-9.6	1000	0.48	0.12
Balegem	11.7	2.4-7.9	1500	0.28	0.20
Gobertange	11.6	2.2-5.7	1500	0.26	0.20

Table 2 : Porosity and hardness of treated and untreated samples.

2.4 Temperature measurements

It was found earlier that the temperature rises fairly high during the polymerization of acrylics in tuff. Therefore the temperature measurements were repeated in the other samples. The shape of all curves is comparable to the observed one in tuff, but the maximum temperature is different in all experiments.

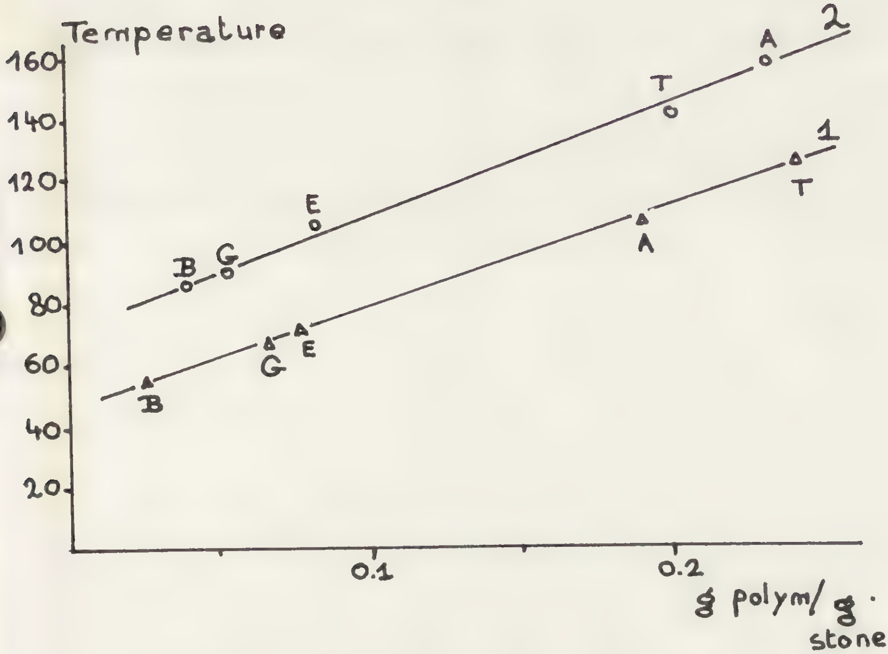

Fig.2: Temperature duering polymerization.

B : Balegem
G : Gobertange
E : Enville
A : Avesnes
T : Tuff

1 : gamma polymerization

2 : radical polymerization

2.5 Partial Impregnation :

It is not always necessary or even recommendable to fill as much as possible all pores with polymer. Attempts were made to consolidate stone by partially impregnations. This can be achieved by placing the sample in a monomer mixture, about 1 cm high. The tests are carried out in a closed space in order to work in a saturated vapor of the monomers. The stone is impregnated by capillary absorption of the monomers. The treatment is stopped as soon as the liquid reaches the upper side of the sample. All experiments were carried out on blocs of the same size (5 x 5 x 5 cm) and as can be seen from the results in table 3, the consolidation by capillary absorbed monomer, and also the time necessary for this, is proportional to the porosity of the sample.

New Balgem and Gobertange cannot be impregnated in this way, but with aged samples this was quite possible. By comparing the results in table 1 and table 3, the consolidation by capillary absorption results in a decrease in the amount of polymer in the stone.

	Wm/Ws	Wp/Ws	Impregnation time (min)	Porosity (%)
Tuff	0.28	0.20	1.20	50
Avesnes	0.17	0.17	55	41.2
Euville	0.056	0.047	30	18.5

Tabel 3 : Consolidation by capillary absorption.

2.6 Consolidation of larger objects.

Aged, sculpted samples of Balegem and Euville, refuse from a restored church, were impregnated and consolidated in order to test if the method can be scaled up to larger objects. Samples, varying in weight from 4 till 7.8 kg were treated with the monomer mixture at which 1 mol % BPO was added. Tests showed that for these larger objects a polymerization temperature of 80°C is needed. At 65° crack can occasionally occur. As shown in table 4 it is also possible for these larger samples to control the amount of polymer in the stone by partial impregnation.

	Weight (kg)	Wm/Ws	Wp/Ws
Balegem	4.170	0.16	0.12
Balegem	7.800	0.11	0.10
Balegem	6.900	0.087	0.059
Euville	4.390	0.048	0.039

Tabel 4 : Consolidation of larg samples of aged Balegem and Euville.

2.7 Consolidation with polyester :

The use of polyester as consolidation agent for stone in extensively described by Rammière and de Tassigny (6,7). As treatments with acrylic monomers

can be realized in an easy way and with good results by using initiators such as AIBN and BPO we tried to use the same method for the consolidation of stone with polyesters. The mixture, used for the impregnations was prepared by adding 20 g of a solution of 1 mol % initiator in styrene to 80 g of Stratyl A 228. Depending on the porosity of the stone the impregnation can be carried out under vacuum or by capillary absorption. After the impregnation the stone is placed in an oven at 65°C and the polyester is allowed to polymerize. In order to prevent the evaportion of the styrene the sample can be wrapped in aluminium foil or the polymerization can be carried out under water. Experiments were carried out on the five kinds of stone and as can be seen from table 5 in all cases the results were excellent. Cracks were never observed.

	Ws	Wm/Ws	Wp/Ws
Tuff	151	0.34	0.30
Avesnes	238.5	0.29	0.27
Euville	281	0.071	0.069
Balegem	318,5	0.047	0.045
Gobertange	302	0.046	0.044

Tabel 5 : Consolidation with polyester, polymerized with a radical initiator.

2.8 Polymerization by gamma irradiation

In our previous work we found it very difficult to consolidate tuff of Maastricht by impregnation with acrylic monomers and polymerization with γ -rays. By means of a Gammacell 220 a more systematic study was realized. Using different screens, experiments were carried out reducing the initial dose rate of 1.77 Mrad/h to 47.2, 33.2, and 10.3 %. The total irradiation time was adapted in order to obtain in all cases a total dose of 3 Mrad. As can be seen in table 6 in all cases cracks occured. The fact that the cracks are worser when the dose rate is smaller confirms the theory that the cracks are caused by the shrinkage during the polymerization. In order to obtain as much radicals as possible during the initial stage of the polymerization, initiators such as AIBN or BPO were added to the monomer

mixture. With a maximum dose rate and the addition of an initiator it was possible to consolidate tuff without the appearence of cracks. The same experiments were carried out with the other stones. For Balegem, Avesnes and Gobertange we didn't succeed in realizing a good consolidation. Even with the addition of an initiator cracks occured. Euville on the contrary never showed cracks. With or without initiator, at high or low dose rates, all experiments resulted in a good consolidation of the samples.

	Dose Rade (Mrad/h)	Initiator	Ws	Wm/Ws	Wp/Ws	Result
Tuff	1.77	-	162	0.34	0.11	+
	0.835	-	151	0.34	0.19	-
	0.596	-	151	0.32	0.14	+
	0.182	-	119	0.33	0.08	++
	1.77	+	238	0.34	0.26	-
	1.77	+	164	0.32	0.26	-
Avesnes	1.77	-	256	0.23	0.21	+
	0.835	-	301	0.22	0.16	++
	0.596	-	294	0.23	0.16	++
	1.77	+	298	0.21	0.19	+
	0.155	+	252	0.22	0.21	+
Euville	1.77	-	354	0.085	0.071	-
	0.835	-	357	0.079	0.074	-
	0.551	-	243	0.080	0.077	-
	0.155	-	398	0.085	0.055	+
	1.77	+	310	0.080	0.077	-
Balegem	1.77	-	338	0.043	0.015	++
	0.835	-	343	0.037	0.032	+
	0.596	-	284	0.044	0.027	++
	0.182	-	270	0.034	0.007	+
	1.77	+	351	0.046	0.025	++
Gobertange	1.77	-	418	0.054	0.042	++
	0.835	-	408	0.055	0.043	+
	0.596	-	301	0.048	0.032	-
	0.182	-	351	0.084	0.048	++
	1.77	+	387	0.073	0.068	++

Tabel 6 : irradiation polymerization
- = no cracks observed
+ = cracks observed after polymerization
++ = heavy cracks observed after polymerization

3. Conclusion

From the results obtained in this investigation can be concluded that it is possible to consolidate tuff of Maastricht, Avesnes, Euville, Balegem and Gobertange by impregnation with a 50/50 mixture of methyl acrylate/ethyl methacrylate (at which 1 mol % AIBN or BPO is added) and polymerization at elevated temperature. Depending on the dimensions of the sample, the temperature should be 65 or 80°C. The method needs only a minimum of apparatus and can be executed by a moderatly trained personel. Although polyester is not a very good material to use for such consolidation purposes, it is possible to use it in the same way as acrylics. This means that the consolidation of stone is also accessible to those who are not in the possibility of using the expensive irradiation apparatus.

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81/10/2

REMOVAL OF COPPER SALTS OFF THE MARBLE

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Working Group: Stone

REMOVAL OF COPPER SALTS OFF THE MARBLE

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Marble and bronze are widely used in sculptural and architectural works. The combination of these two materials in one monument results in staining the marble with the products of the copper corrosion. A film-forming mixture based on the water solution of the polyvinyl alcohol, ammonia and the polymerized sulphoacid cationite was used to clean marble. This mixture is applied to the stained area; the forming combinations of ammonia and copper migrate from the marble to the solution where they are attracted by the cationite. Water expiring, a film of the polyvinyl alcohol is formed; this film includes the grains of the cationite which absorb ions of copper. The film can be easily removed without injuring the marble structure.

Since old days marble and bronze have been widely used in sculptural and architectural works. Their tech-

cal and decorative qualities have proved their efficiency in various monuments. It is rather often that architects and sculptors combine these materials in one monument. This combination is observed in many memorial plaques, bronze busts, sculptures with marble bases, etc. In all these cases bronze and marble are attacked by corrosion; water brings the products of corrosion to the lower parts of the monument where they get fixed. The products of the bronze corrosion (oxides, hydroxides, salts) are kept on the marble surface due to the force of the absorbtion, undergo some chemical changes and get firmly fixed. Inspite of the extremely low solubility of oxides, hydroxides and copper carbonates, they gradually, year after year, penetrate into marble, forming a thick copper layer (3-4 mm). Blue and green stains spoil the marble surface and their removal is among the most important problems of restoration.

Detergents practically do not influence upon the intensity of such stains, acids are not advisable for marble and, what is more important, cannot be effective in this case, as copper compounds and calcium carbonate dissolve equally in many acids. Complexons, for example trylon (di-natrium salt of the ethylene-diamin-tetra-vinegar acid), proved ineffective, too, as they dissolve both copper compounds and marble. Ammonia solutions can remove some copper compounds, but ammonia and copper combinations that form as the result of such treat-

ment are well dissolved in water and penetrate into the crystalline structure of marble and get fixed deep inside.

In order to remove the copper compounds which stain the marble surface several simple coditions should be fulfilled. First of all, the copper compounds fixed in the marble should be transformed into well-soluable elements; then the conditions preventing the new absorbtion of copper ions should be arranged; and, above all, the contact of the reagents with the marble surface should be long enough to allow the diffusion of copper ions from the crystalline structure.

The last requirement can be fulfilled due to the addition of consistent detergents, for example, water-soluable polymers - polyvinyl alcohol, carboxymethyl cellulose, etc.(1)

Many water-soluable complexes are well-known for the ions of copper. Ions of copper make stable compounds with ammonia, which, when dissolved in water, does not destroy marble; this element is widely used in various detergents for marble. It is notable that ammonia dissolves not only salts, but copper hydroxides as well. Copper forms complex combinations with polyatomic alcohol, polyvinyl alcohol, for example (1,2).

There are cases of usage of polyvinyl alcohol for cleaning marble (3-5). Water solutions of polyvinyl alcohol (10-20%) are jellies which, on drying, form a

flexible film including the unspecific dirt ; this film can be easily removed from the surface due to its low adhesion. Polyvinyl alcohol together with ammonia dissolves well copper salts and hydroxides, but its capacity is rather low and while the water and ammonia evaporate the copper ions get free; these copper ions settle down on the marble surface. To improve the cleaning mixture a metabolic cation resin was added. After long experiments the sulphoacid cationite KY-2, polymerized, was chosen due to its high capacity for the complexes of ammonia and copper (6,7). As a result, a new compound (8) was formed, efficient for cleaning marble. It consists of polyvinyl alcohol (20%), ammonia and metabolic cation resin in the form of NH^{+}_{4}.

Due to the polyvinyl alcohol in the compound, the substance receives a high viscosity and is well preserved on the vertical surfaces; it keeps the necessary concentration of ammonia ions to provide the reaction with copper. The metabolic cation resin in the form of NH_4^+ shifts the equilibrium in the system.

$$CuCO_3 \cdot Cu(OH)_2 \dashrightarrow [Cu(NH_3)_4]^{\cdot\cdot} \dashrightarrow RSO_3\,[Cu(NH_3)_4]$$

The permanent elimination of the complex copper ions from the solution according to the given formulation facilitates the migration of copper ions from marble into the solution. As the solution dries, a polyvinyl film with the grains of cationite absorbing ions of copper appears on the surface. The film can be easily re-

moved from the marble without spoiling its smoothness. After laboratory testing the compound has been successfully used in cleaning the marble memorial plaques with bronze details.

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81/10/3

THE CONSOLIDATION OF STONE BY IMPREGNATION WITH ACRYLIC MONOMERS

E. de Witte and C. Bataillie

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SUMMARY

The consolidation of 5 building materials is investigated: Tuff of Maastricht, Avesnes, Euville, Balegem, and Gobertange.
As well smaller as larger samples can be consolidated by impregnation with a 50/50 mixture of methyl acrylate / ethyl methacrylate at which 1 mol % initiator is added. The temperature should be at least 65°C, for larger samples 80°C.

Good results can also be obtained by radical polymerization of polyesters. Experiments with gamma irradiation showed that in many cases cracks are obtained and that the best way to avoid these is by adding initiators to the monomer mixture and by working at high dose rates.

1. Introduction

In previous papers (1,2,3) we reported the consolidation of tuff of Maastricht by impregnation with a mixture of methyl methacrylate and ethyl acrylate, followed by polymerization at elevated temperature. The results showed that the following experimental conditions can be used:
- impregnation under vacuum with a 50/50 mixture of methyl methacrylate/ethyl acrylate, at which 1 mol % azo-bis-iso-butyronitrile (AIBN) is added.
- polymerization by heating the impregnated stone at a temperature of at least 65°C.

Polymerizations initiated by gamma irradiation showed the appearence of cracks in the stone.

In this work the experiments were enlarged to 5 different kinds of materials: Tuff, Balegem, Euville, Avesnes and Gobertange.
Experimental conditions were tested out to obtain good consolidations of these materials by using radical and γ-polymerization. Also polyester was used to carry out consolidation, but in stead of gamma irradiation a radical initiation was used.

2. Results and Discussion

2.1 Radical Polymerizations

The impregnations were carried out as described before, but in stead of using methyl methacrylate and methyl acrylate as impregnating agent, a 50/50 mixture of ethyl methacrylate and methyl acrylate was used. We changed over to this monomer mixture as it was found meanwhile (4) that this are the monomers used to prepare Paraloid B 72, a well known product and one of the most stable polymers used in conservation (5). As initiator, as well AIBN as benzoilperoxide (BPO) can be used. As shown in figure 1, the reaction will be somewhat faster when using AIBN: the reaction takes place after 1 hour, with BPO as initiator only after 1 h 20'.
The five kinds of stone were treated in the same way and as can be seen from the results in table 1 the degree of impregnation is proportional to the porosity of the non treated stone.

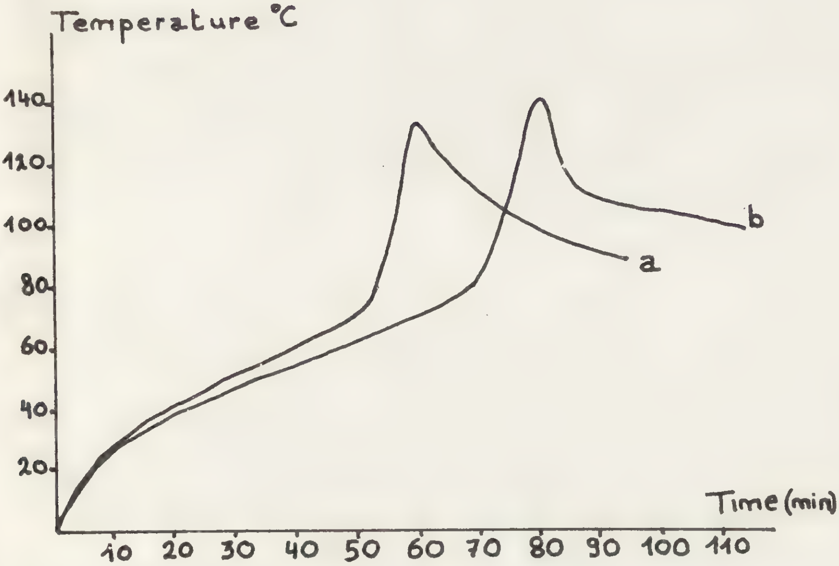

Fig.1: Temperature in Tuff duering polymerization.
a: AIBN
b: BPO

All polymerizations resulted in a good consolidation. Cracks were never observed. This proves that the experimental conditions, as they were defined for tuff, are also suitable for the 4 other materials.

	Ws	Wm	Wm/Ws	Wp/Ws	P(%)
Tuff	170.3	39.7	0.35	0.25	50
Avesnes	172	43.7	0.25	0.23	41.2
Euville	339	28.9	0.085	0.083	19.5
Balegem	326.1	17.4	0.053	0.046	11.7
Gobertange	298	16	0.054	0.051	11.6

Table 1 Consolidation of 5 building materials
Ws : Weight of stone in grams
Wm : Weight of absorbed monomer
Wp : Weight of polymer in the sample
P : Porosity of the non treated sample.

In order to have an idea of the changes in properties, due to the impregnation, the porosity and the hardness of the different samples were determined.

2.2 Porosity

The porosity, in volume percent, was measured by weighting the sample dry (Wd) and impregnated with water (Ww). Subsequently the stone is weighted under water in order to determine the exact volume of the stone (Wo). The porosity can be calculated from these three values. From the results in tabel 2 follows that the porosity decreases in all cases. The differences which are observed for the treated samples are caused by variations in the amount of polymer in the stone. Depending on the Wp/Ws ratio a range of porosities can be obtained.

2.3 Hardness:

The hardness was measured as described in our earlier work. The weight of the widia knife was adopted to the hardness of the stone on order to obtain a scratch of a good measurable widthness. All experiments were carried out in five fold and the results in table 2 are average values.
Except for Euville, the hardness of the four other stones is comparable after treatment. This means that the softer the original material is, the largest the increase in hardness will be.

	P (%)		Hardness		
	Untreated	treated	Weight on Knife (g)	Width of scratch (mm)	
Tuff	50	17.5-25.3	500	1.29	0.25
Avesnes	41.2	5-15	700	0.78	0.22
Euville	19.5	3.2-9.6	1000	0.48	0.12
Balegem	11.7	2.4-7.9	1500	0.28	0.20
Gobertange	11.6	2.2-5.7	1500	0.26	0.20

Table 2 : Porosity and hardness of treated and untreated samples.

2.4 Temperature measurements

It was found earlier that the temperature rises fairly high during the polymerization of acrylics in tuff. Therefore the temperature measurements were repeated in the other samples. The shape of all curves is comparable to the observed one in tuff, but the maximum temperature is different in all experiments.

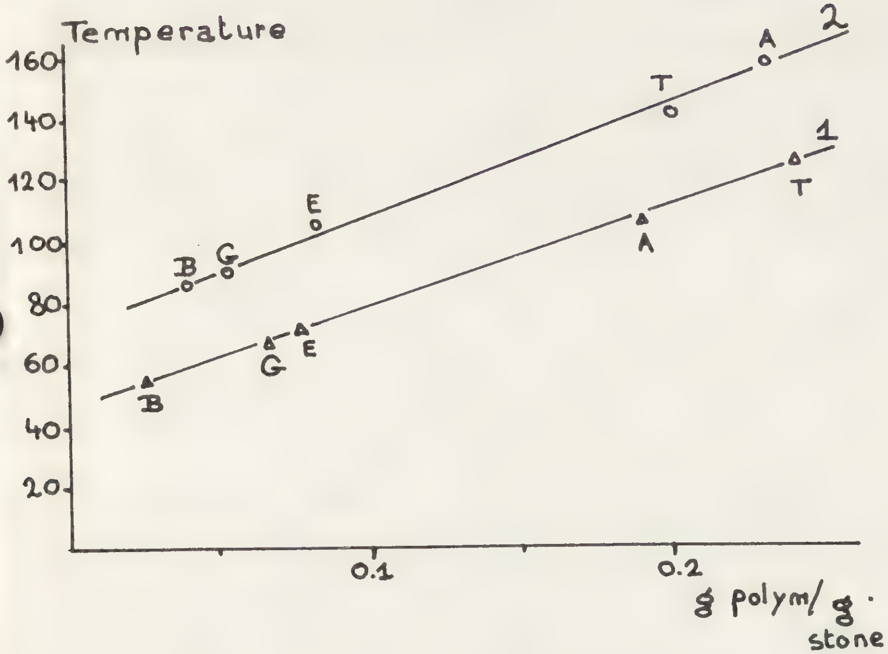

Fig.2: Temperature duering polymerization.

B : Balegem
G : Gobertange
E : Enville
A : Avesnes
T : Tuff

1 : gamma polymerization

2 : radical polymerization

2.5 <u>Partial Impregnation</u> :

It is not always necessary or even recommendable to fill as much as possible all pores with polymer. Attempts were made to consolidate stone by partially impregnations. This can be achieved by placing the sample in a monomer mixture, about 1 cm high. The tests are carried out in a closed space in order to work in a saturated vapor of the monomers. The stone is impregnated by capillary absorption of the monomers. The treatment is stopped as soon as the liquid reaches the upper side of the sample. All experiments were carried out on blocs of the same size (5 x 5 x 5 cm) and as can be seen from the results in table 3, the consolidation by capillary absorbed monomer, and also the time necessary for this, is proportional to the porosity of the sample.

New Balgem and Gobertange cannot be impregnated in this way, but with aged samples this was quite possible. By comparing the results in table 1 and table 3, the consolidation by capillary absorption results in a decrease in the amount of polymer in the stone.

	Wm/Ws	Wp/Ws	Impregnation time (min)	Porosity (%)
Tuff	0.28	0.20	1.20	50
Avesnes	0.17	0.17	55	41.2
Euville	0.056	0.047	30	18.5

Tabel 3 : Consolidation by capillary absorption.

2.6 Consolidation of larger objects.

Aged, sculpted samples of Balegem and Euville, refuse from a restored church, were impregnated and consolidated in order to test if the method can be scaled up to larger objects. Samples, varying in weight from 4 till 7.8 kg were treated with the monomer mixture at which 1 mol % BPO was added. Tests showed that for these larger objects a polymerization temperature of 80°C is needed. At 65° crack can occasionally occur. As shown in table 4 it is also possible for these larger samples to control the amount of polymer in the stone by partial impregnation.

	Weight (kg)	Wm/Ws	Wp/Ws
Balegem	4.170	0.16	0.12
Balegem	7.800	0.11	0.10
Balegem	6.900	0.087	0.059
Euville	4.390	0.048	0.039

Tabel 4 : Consolidation of larg samples of aged Balegem and Euville.

2.7 Consolidation with polyester :

The use of polyester as consolidation agent for stone in extensively described by Rammière and de Tassigny (6,7). As treatments with acrylic monomers

can be realized in an easy way and with good results by using initiators such as AIBN and BPO we tried to use the same method for the consolidation of stone with polyesters. The mixture, used for the impregnations was prepared by adding 20 g of a solution of 1 mol % initiator in styrene to 80 g of Stratyl A 228. Depending on the porosity of the stone the impregnation can be carried out under vacuum or by capillary absorption. After the impregnation the stone is placed in an oven at 65°C and the polyester is allowed to polymerize. In order to prevent the evaportion of the styrene the sample can be wrapped in aluminium foil or the polymerization can be carried out under water. Experiments were carried out on the five kinds of stone and as can be seen from table 5 in all cases the results were excellent. Cracks were never observed.

	Ws	Wm/Ws	Wp/Ws
Tuff	151	0.34	0.30
Avesnes	238.5	0.29	0.27
Euville	281	0.071	0.069
Balegem	318,5	0.047	0.045
Gobertange	302	0.046	0.044

Tabel 5 : Consolidation with polyester, polymerized with a radical initiator.

2.8 Polymerization by gamma irradiation

In our previous work we found it very difficult to consolidate tuff of Maastricht by impregnation with acrylic monomers and polymerization with γ -rays. By means of a Gammacell 220 a more systematic study was realized. Using different screens, experiments were carried out reducing the initial dose rate of 1.77 Mrad/h to 47.2, 33.2, and 10.3 %. The total irradiation time was adapted in order to obtain in all cases a total dose of 3 Mrad. As can be seen in table 6 in all cases cracks occured. The fact that the cracks are worser when the dose rate is smaller confirms the theory that the cracks are caused by the shrinkage during the polymerization. In order to obtain as much radicals as possible during the initial stage of the polymerization, initiators such as AIBN or BPO were added to the monomer

mixture. With a maximum dose rate and the addition of an initiator it was possible to consolidate tuff without the appearence of cracks. The same experiments were carried out with the other stones. For Balegem, Avesnes and Gobertange we didn't succeed in realizing a good consolidation. Even with the addition of an initiator cracks occured. Euville on the contrary never showed cracks. With or without initiator, at high or low dose rates, all experiments resulted in a good consolidation of the samples.

	Dose Rade (Mrad/h)	Initiator	Ws	Wm/Ws	Wp/Ws	Result
Tuff	1.77	-	162	0.34	0.11	+
	0.835	-	151	0.34	0.19	-
	0.596	-	151	0.32	0.14	+
	0.182	-	119	0.33	0.08	++
	1.77	+	238	0.34	0.26	-
	1.77	+	164	0.32	0.26	-
Avesnes	1.77	-	256	0.23	0.21	+
	0.835	-	301	0.22	0.16	++
	0.596	-	294	0.23	0.16	++
	1.77	+	298	0.21	0.19	+
	0.155	+	252	0.22	0.21	+
Euville	1.77	-	354	0.085	0.071	-
	0.835	-	357	0.079	0.074	-
	0.551	-	243	0.080	0.077	-
	0.155	-	398	0.085	0.055	+
	1.77	+	310	0.080	0.077	-
Balegem	1.77	-	338	0.043	0.015	++
	0.835	-	343	0.037	0.032	+
	0.596	-	284	0.044	0.027	++
	0.182	-	270	0.034	0.007	+
	1.77	+	351	0.046	0.025	++
Gobertange	1.77	-	418	0.054	0.042	++
	0.835	-	408	0.055	0.043	+
	0.596	-	301	0.048	0.032	-
	0.182	-	351	0.084	0.048	++
	1.77	+	387	0.073	0.068	++

Tabel 6 : irradiation polymerization
- = no cracks observed
+ = cracks observed after polymerization
++ = heavy cracks observed after polymerization

3. Conclusion

From the results obtained in this investigation can be concluded that it is possible to consolidate tuff of Maastricht, Avesnes, Euville, Balegem and Gobertange by impregnation with a 50/50 mixture of methyl acrylate/ethyl methacrylate (at which 1 mol % AIBN or BPO is added) and polymerization at elevated temperature. Depending on the dimensions of the sample, the temperature should be 65 or 80°C. The method needs only a minimum of apparatus and can be executed by a moderatly trained personel. Although polyester is not a very good material to use for such consolidation purposes, it is possible to use it in the same way as acrylics. This means that the consolidation of stone is also accessible to those who are not in the possibility of using the expensive irradiation apparatus.

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81/10/4

WEATHERING OF BUILDING MATERIALS OF THE GIRALDA (SEVILLE, SPAIN) BY LICHENS

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ABSTRACT

The weathering of stones and bricks of the Giralda (a Moorish tower) of Seville caused by lichen action has been studied. The most abundant lichens are *Lecania erysibe*, *Caloplaca decipiens*, *Lecanora albescens* and *Xanthoria parietina*. The moss *Tortula muralis* is also present. The role of these organisms in the weathering of urban monuments is discussed.

The most outstanding monument of Seville is without any doubt the Giralda, a Moorish tower with a Christian superstructure. This tower was originally the minaret of the largest Mosque in Seville; it was built between 1184 and 1196 using Roman building stones for the foundations and bricks for the edifice. In 1565-68 the architect Hernan Ruiz added a belfry with 25 bells, with an enormous bronze statue on the top, which serves as a weather vane. The height of the Giralda is 94 metres.

In past centuries the tower suffered from several earthquakes but the greatest damage to it today is caused by weathering of the building stones of the belfry. The belfry walls show evident signs of deterioration, being almost covered with a dark, compact, homogeneous crust, detached in many areas leaving the original yellow limestone exposed to subsequent attacks. A detailed study of this crust is the subject of another communication (Saiz-Jimenez and Bernier, 1981). This paper advances preliminary results on the lichens involved in the deterioration of the belfry.

Centres of urban and old industrial towns support very few lichen species and in the areas of highest pollution buildings, walls and monuments of acid stone,

and trees, remain completely uncolonized. Calcareous substrates are more favourable than non-calcareous substrates to bryophyte and lichen colonization. The high pH of such substrates as mortar, asbestos-cement and limestone provides a buffering effect on the toxicity of the urban environment (Seaward, 1975). Thus, the behaviour of lichens in polluted areas is to some extent governed by the nature of the substrate. Species occupying acidic substrates are usually far more sensitive to sulphur dioxide than those present on basic substrates. Sensitive species disappear first from trees and then sandstone walls, while calcareous stones and asbestos-cement roofs retain their flora longest. The urban climate reduces species diversity, and the limited number of lower plants to be found in urban areas have a high reproductive capacity and a tenacious hold on the substrates they colonize (Gilbert, 1973; Seaward, 1979).

Stambolov and van Asperen de Boer (1972) stated that lichens cannot tolerate soot or sulphate and are therefore unlikely to attack buildings and monuments in urban and industrial areas. However, LeBlanc and Rao (1975) reported that the different species of lichens and bryophytes show considerable variations in their susceptibility to injury by air pollution, especially sulphur dioxide. Characteristically, a few species are toxitolerant, taking advantage of the reduced competition, or they may be actually stimulated metabolically by certain pollutants present in the urban and industrial environments.

According to Hueck-van der Plas (1968), lichens are involved in stone weathering in different ways:
(a) through increase of their mass as they grow;
(b) through changes in volume in wet and dry periods resulting in repeated relaxation and shrinking of the colony - this is particularly important for organisms with a strong adhesion to the surface;
(c) through their water-binding capacity, whereby they can exert considerable force in winter frosts;
(d) and finally through the excretion of organic acids.

However, the effectiveness of lichens as agents for rock weathering has been discussed for many years and opinions have varied widely. On the one hand, it has been claimed that both the physical and chemical action of lichen on bare rock surfaces are of great significance and, on the other, that such action has been grossly exaggerated. There is certainly no doubt that lichens are involved in the mineral weathering and the rock/lichen interface is, in fact, an ideal location for the study of the microbiological weathering of minerals since, unlike the situation in soil, the influence of a single organism on any one mineral, or on a variety of minerals, can be easily investigated (Jones et al., 1980).

Syers and Iskandar (1973) have reviewed the ways by which lichens are able to decompose minerals. They concluded that rhizine penetration and thallus expansion and contraction cause mechanical disintegration on the substrate. The significance in biogeochemical weathering of hydrogen ions furnished by the dissolution of carbon dioxide in water is unknown but is expected to be small. Similarly, oxalic acid produced by lichens is probably of minor importance in biogeochemical weathering. Soluble metal complexes are formed when lichen compounds are allowed to react with minerals and rocks in the laboratory. This provides a satisfactory explanation for mineral degradation under experimental conditions but does not appear to have been demonstrated in the field, although chemical and mineralogical changes in the substrate below lichen thalli indicate that this weathering could occur under field conditions.

According to Seaward (1979) information relating to the colonization of algae, bryophytes and lichens on urban buildings is fragmentary and widely scattered in scientific literature, and detailed surveys on the cryptogamic flora have unfortunately not been undertaken in urban areas. Therefore, it appears of interest to investigate the colonization of fresh surfaces by lichens and mosses and specifically their role in the deterioration of the belfry limestone and bricks of the Giralda. Scanning electron microscopy which permits detailed analysis of the structures of these organisms was used (Hale, 1976).

Two differentiated zones can be discerned in the area studied at a height of 50 to 85 metres, which corresponds with the belfry floor to the bronze statue base. One of them comprises the balustrades of four balconies and their limestone ornamentations; the other is made up of the brick and mortar outer walls of these floors.

The limestone supports a species-poor lichen flora, especially when compared with other monuments, as for example the Notre-Dame de l'Epine basilica (Deruelle et al., 1979), composed of Lecania erysibe (Ach.) Mudd, Caloplaca decipiens (Arn.) Jatta, Lecanora albescens (Hoffm.) Floerke, Xanthoria parietina (L.) Betr., Candelariella medians (Nyl.) A.L. Sm., Lecanora dispersa (Pers.) Rohl., Phaeophyscia orbicularis (Neck.) Poetsch, Caloplaca cf. flavovirescens (Wulf.) DT and Sarnth., and Caloplaca dolomiticola (Hue) Zahlbr.

These lichens occur on exposed surfaces, where the supply of water and nutrients is sporadic and, consequently, they may have to withstand periods of desiccation as in summer, when no water is available either as rain or fog. They are located on the front stones oriented to all the four cardinal points. On the

southern front Lecanora muralis (Schreb.) Rabenh. is also found.

All the above mentioned species are usually found on flat, perpendicular and sloping surfaces, in the upper parts of the balustrade and its ornamentations, whereas the lower parts were mostly bare, with small and patchy colonies of Lecania erysibe.

The distribution of species is not very homogeneous, due to environmental gradients which favours dispersion. Differential distribution of nutrients and minerals also play an important role in lichen colonization, because the action of rain on stones causes absorption of water depending on their porosity and density. Acid rain (common in urban and industrial sites) leaches out the calcium ions from the surface, causing it to crumble away, generating channels and cracks. The water dissolves and bring with it salts in solution to the interior of stones. The drying out of the stone results in the formation of saline deposits on the surface. This creates favourable niches for microbial growth which enrich the stones in nitrogeneous compounds. However, in this investigation lichen establishment was encouraged by pigeon excrement, high in nitrogen and phosphorous, widely distributed all over the belfry. In this connection, the lichens reported here are considered as ornithocoprophilous (Brodo, 1973; James et al. 1977) and are often associated with limestone, bone and neutral-barked trees.

The bricks and mortar from the belfry outer walls support a few lichen species with a scanty and diffuse distribution. Species identified were Lecania erysibe, Candelariella medians, Lecanora dispersa, Caloplaca aurantia (Pers.) Hellb., Caloplaca teicholyta (Ach.) Steiner and Acarospora sp. (subgenus Acarospora). In this case, the perpendicular wall surfaces may afford the lichens some measure of protection against mechanical wear, and the pigeons' influence on colonization cannot be as important as in exposed belfry stones. This and the distinct substrate constitution may explain the differences in lichen species.

Also the moss Tortula muralis (L.) Hedw. was observed. This is adapted to shallow or primitive soils formed at the junction between stones, and in holes, cavities and protected places where dust and particulate matter is deposited by the wind. It was found that small rhizoids penetrate the limestone where they extend like a net, probably through pores and microfissures. In some cases, Phaeophyscia orbicularis was found growing on Tortula muralis.

Most man-made substrates tend to be rather alkaline and this exerts a neutralizing effect on sulphurous

pollutants and enables lichens to extend further into towns on asbestos-cement, concrete and limestone (Seaward, 1975). Xanthoria parietina appears on these materials at mean winter sulphur dioxide levels of about 125 ug/m^3. In Britain common urban lichens include Lecanora dispersa, Candelariella aurella and Lecania erysibe, all on asbestos-cement or similar calcareous substrates. These species show an enhanced resistance to air pollution, as does the moss Tortula muralis (Gilbert, 1973). Other species (Caloplaca aurantia, Caloplaca teicholyta, Candelariella medians) were also reported to be of interest in air pollution survey works (Hawksworth and Rose, 1976).

The range of lichen species observed leads to believe that the atmosphere is not highly polluted, but probably moderately polluted (mean year 1976-80 sulphur dioxide level of about 90 ug/m^3) and the flora is more-or-less representative of "semi-natural" calcareous substrates influenced by bird excrement (Seaward, personal communication).The community is a Caloplacion decipientis Klem. near to Caloplacetum murorum (DR.) Kaiser. The association occurs on a soft, decayed calcareous substrate enriched by bird excrement, is very nitrophilous, photophilous, xerophilous and sulphur dioxide-air pollution tolerant.

The importance of lichens as protective or detrimental organisms for stone monuments has been pointed out by Lallement and Deruelle (1978). It is true that lichens often create a "living barrier" to acid rain water attack, but in our case the lichens are harmful. Epilithic crustose lichens such as Lecania erysibe have an outer cortex with a layer of closely packed cells, an algal layer (figure 4) and a medulla, consisting of loosely interwoven hyphae in periclinal arrangement (figure 5), which is attached directly to the substrate (figure 6) where the hyphae are involved in disintegration and decomposition of stone, either through contraction which creates a pulling strain during dry periods or through dissolution by excreted lichen acids. It seems probable that Lecania erysibe has some detrimental effects on the limestone, because removal of the lichen also detaches a thin film of about 1-2 mm of substrate. Furthermore, crystals of lichen acids,embedded on the medullary hyphae, may act as metal-complexing agents and this promotes biogeochemical weathering, as reported by Syers and Iskandar (1973). Caloplaca spp. have also been found firmly attached to the substrate, causing detachment of particles when removed from the limestone.

In addition to limestone weathering, the lichens thriving on the Giralda produce an unpleasant appearance which causes darkening of surfaces. It is recommended to

the architect-restorer that a conservation treatment should be carried out, involving cleaning and removal of the organisms. Sterilization with appropriate biocides is suggested because, in addition to lichens and bryophytes, bacteria and fungi were found growing directly on the stone. Consolidation of weathered stones and a water-proofing treatment are also necessary as pointed out by Tiano (1978).

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Figure 1. Detail of the Giralda belfry.

Figure 2. Detail of a weathered limestone by Lecania erysibe. Detached parts were also covered by the lichen.

Figure 3. Stones colonized by Lecania erysibe and Xanthoria parietina.

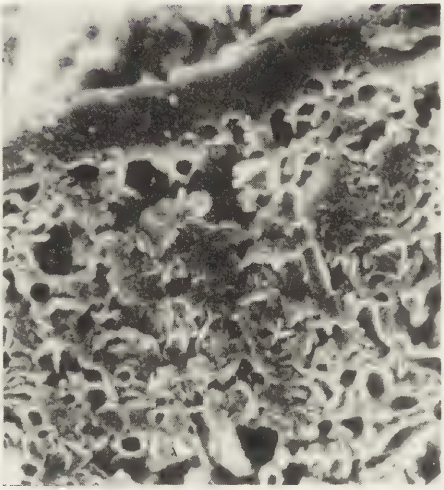

Figure 4. Cross section of Lecania erysibe showing outer cortex and algal layer. x1800

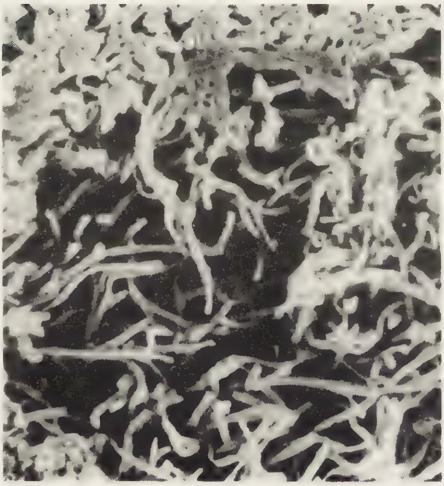

Figure 5. Plectenchyma of interwoven hyphae of Lecania erysibe. x800

Figure 6. Attachment of hyphae of Lecania erysibe to the substrate. x1000

81/10/5

GYPSUM CRUSTS ON BUILDING STONES. A SCANNING ELECTRON MICROSCOPY STUDY

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Working Group: Stone

GYPSUM CRUSTS ON BUILDING STONES. A SCANNING ELECTRON MICROSCOPY STUDY

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ABSTRACT

The gypsum crusts of some of the most outstanding monuments of Seville, Spain, has been studied. They include the Giralda (a Moorish tower), the Cathedral and the City Hall. Sulphur dioxide-polluted air and airborne carbon particles from car emissions are important factors in the formation of these crusts.

The deteriorating quality of urban and urban-industrial atmospheres has greatly accelerated the decay rate of the natural stone of buildings and monuments.

Natural building stones may be obtained from igneous, sedimentary or metamorphic rocks. Sedimentary rocks provide the main Spanish building stones: limestones and sandstones. The original deposit from which they were formed consisted of loose, uncemented particles produced by the weathering of earlier rock, by accumulation of animal skeletons or by chemical deposition in lakes and seas. In the course of time, the sediments become cemented together to form porous, coherent masses. Limestones consist mainly of calcium carbonate; sandstones of quartz.

In nature, the alteration of calcium carbonate is brought about by solution due to the action of rain water directly at the surface and, especially, of water circulating underground. This action is enhanced by the presence of acidic oxides (CO_2, SO_2, SO_3, NO_x). According to Stambolov (1967) combustion of sulphur-containing materials produces, besides sulphur dioxide, sulphur trioxide also, but normally in the ratio 10:1. Various

oxidation mechanisms in the atmosphere are likely to change this ratio in favour of the sulphur trioxide proportion. Catalists like transition metal ions-Fe(III), Mn(II), Cu(II), Co(III)-bring about a considerable oxidation of SO_2 to SO_3. Sunlight and moisture may also be the cause of oxidation. In contact with water, sulphur dioxide and sulphur trioxide form respectively sulphurous and sulphuric acids. More recently, Tomasi et al. (1975) have shown that the concentration of sulphate ions observed in the atmosphere is the result of chemical reactions occurring inside the atmospheric system constituted by SO_2, liquid water and NH_3. Airborne particles also play a fundamental role in the catalytic reaction of SO_2 in water.

Contact of sulphur dioxide-polluted air with calcium carbonate produces on their exposed surfaces a dirty, hard crust of gypsum. The dark colour is due to the incorporation of sand, soot, tar and fly ash particles.

This paper reports preliminary work on the black crusts of some of the most outstanding monuments of Seville, Spain. They include the Giralda (a Moorish tower), the Cathedral and the City Hall.

The three monuments are in the centre of the town, an area with intensive car traffic, which produces an atmosphere of carbon monoxide, oxides of nitrogen, hydrocarbons, lead-containing compounds and other substances from the car fumes, along with high smoke and sulphur dioxide levels, which often occur in urban areas.

In the urban centre of Seville there are a few sulphur dioxide and smoke recording gauges which have been in operation since 1975. The data are a very significant collection of relevant material, which appears to be valid for the understanding of the effect of pollution on monuments. Table 1 shows mean season sulphur dioxide and smoke concentrations for 1976-80 and mean season relative humidity, maximum and minimum temperatures and total rainfall for 1961-80.

TABLE 1

Climatic and environmental conditions in Seville

season	SO2 ug/m3	smoke ug/m3	RH %	max T(°C)	min T(°C)	total rainfall (mm)
Spring	93	143	61	25.8	12.4	110
Summer	84	141	54	34.2	17.4	25
Autumn	87	210	74	20.3	9.1	237
Winter	84	203	76	17.0	6.7	254

It is noteworthy that sulphur dioxide levels were almost constant through the year, with no significant seasonal variations. It has been stated for other cities,

as Milan for instance, that the sulphur dioxide level falls drastically during the summer, confirming that the main source of this contaminant in urban areas is domestic heating (Tomasi et al., 1975). This is not the case for Seville where heating is mainly by electric power, which may explain the absence of seasonal fluctuations.

Scanning electron microscopy has been proved to be a valuable technique for diagnosis of diseased stone and for studying the mechanisms of formation of inorganic substances on stone surfaces (Lewin and Charola, 1978; Charola and Lewin, 1979).

For this study, fragments of the crusts were cemented to sample stubs, coated with carbon and then with gold and examined in a scanning electron microscope (Hitachi model HHS-2R) interfaced with an energy dispersive analyser of X-rays (EDAX). The results were as follow:

The Giralda. The building stones of the belfry of the Giralda are of different limestone types. The balustrade stone mostly consists of a conglomerate of microfossils cemented by a calcareous matrix. The dissolution of a part of the matrix caused by the acid rain in exposed areas gives rise to a relief of fossils. These eroded parts can be observed in the stones uncolonized by lichens (Saiz-Jimenez, 1981).

Undecayed stone samples from the belfry walls showed a thick layer of compact calcium carbonate (calcite) crystals. EDAX analysis also gave minor amounts of Al, Si, Cl, K and Fe as elemental constituents. Sheltered surfaces are covered by a black, compact, homogeneous crust, detached in many cases. Analysis of this crust yielded as the major component calcium sulphate (gypsum), although crystals of potassium chloride and calcium chloride were found in a few cases. Quartz and aluminosilicates (EDAX analysis provided Al, Si, K, Ca and Fe) also appeared. In one case, a small grain containing Si, Ca and Ti was observed, probably titanite (sphene) sometimes associated with limestones.

Some examples of crusts are presented in figures 1-4. Figure 1 shows a rough, deeply bored surface from which EDAX mostly displays Ca and smaller peaks of S and Si. Traces of Al and Fe are also present. A higher magnification of the hole border reveals gypsum and quartz grains (figure 2). The rough crust may be created by acid rain water dissolution of original calcite. The acid leaches out the calcium ions from the surface, causing it to crumble away, generating channels and cracks and uncovering the more acid-resistant quartz grains that are embedded in the limestone. The drying out of the stone results in the formation and growth of new

crystals on the surfaces and at the pores and channels. As these crystals grow they exert expansive stresses on the surrounding stone and crumble and crack the crust, or the crust flakes away.

Figure 3 discloses a model of gypsum crystal growth on the crust surface and figure 4 presents the oriented crystals at higher magnification. This growth is probably induced by alterations or structural modifications in the stone, and the gypsum crystals nucleate and grow in the zones which show clear structural defects. In fact, Badan et al. (1976) have stated that in places where defects and structural and macroscopic discontinuities are present gypsum is formed and grows differently from the other areas and generally tends to form crystal growing in predetermined directions.

In other crust samples (not shown here) were found either a thick layer of small, compact, randomly oriented crystals or growth in acicular configurations. Also, some crusts exhibit either a network of small cracks or very large fissures (see also figure 3).

Several samples were colonized by very long and scattered fungal hyphae, which is striking because this habitat does not seem favourable to microbial growth. A fungal hypha can also be discerned in figure 1 crossing over a hole.

<u>The Cathedral</u>. The area studied is mostly constituted by sandstone, although some limestone is also present. Two processes can be observed in this stone decay. One of them is the presence of stone blocks which appear worn away even to a depth of about 10 cm. Also there is formation of deep cavities, the surface of which are covered by stone powder. This is the typical form of decay called by the French specialists "maladie alveolaire". It seems that the principal factors involved are the presence of soluble salts and hygrometric variations (Pauly, 1976). The process consists in the mechanical disgregation of the surface layers of the stone by repeated crystallisation of salts brought by the wetting-drying cycles. Furthermore, wind, acting mechanically on the disgregated surface and/or by conveying humidity and heat, plays a role in this deterioration mechanism (Rossi-Manaressi and Ghezzo, 1978).

Another possibility is that in stones that are frequently wetted by rain, the repeated crystallisation of the calcium sulphate dislodges particles of stone which are subsequently washed off, together with the calcium sulphate, during heavy rainfall. The surface of the stone therefore erodes gradually. In most sheltered parts, the gypsum remains in position to form a hard and dirty skin, which eventually blisters to reveal an

underlying layer of crumbling debris.

The black crust of the stones of the Cathedral are characterized by the high gypsum content (as evidenced by the EDAX analysis of the crystals). Total analysis of the crust gave as major elements Ca, S and Si, and as minor elements Al and Fe. Scattered quartz grains are also present. Figure 5 shows an example of this crust, exclusively composed of gypsum. Figure 6 presents together with gypsum and quartz a few fungal hyphae, which are covered by mineral matter. Fungal hyphae and spores were also observed in different samples of this crust.

The City Hall. This limestone building shows the same problems as those previously described for the Cathedral. The crust showed as major elements (determined by EDAX analysis) Ca, S and Si, and Al, Fe, Na, Cl and K as minor elements. In one case Zr was found. Major compound was gypsum, together with a small amount of sodium and calcium chlorides, some calcium carbonate, quartz and aluminosilicates.

Surfaces present cracks and fissures. Figure 7 discloses a typical picture in which gypsum is the major component, with some sodium chloride crystals in the lower part of the micrograph.

To study the composition of the black constituents of the crusts the procedure of del Monte et al. (1980) was adopted. Crusts were ground and then dissolved in 10 N HCl. The insoluble material was washed several times with distilled water and recovered by centrifugation. The material was found to be composed of quartz and aluminosilicates together with airborne carbon particles of spherical shape, rough surface, high porosity and irregular pore distribution (figure 8) as described also by the above mentioned authors. EDAX analysis gave as major elements Si, Ca and S, and as minor elements Zn, Fe and Cu. Cheng et al. (1976) identified these airborne particles with particulate matter emitted from oil fired power plants, but in our case these most probably arise from car emissions. These particles may also be an important deteriorating agent because they contain sulphates, sulphites and sulphur dioxide adsorbed on the surface and bonded to it in different ways (Craig et al., 1974).

From the results reported in this paper it appears evident that sulphur dioxide-polluted air is one of the most important factors in the deterioration of the monuments located in the urban centre of Seville, as is suggested by the almost uniform black gypsum crust covering these monuments. The combined action of all air pollutant (gases and solid particles) blackens the buildings and cover them with blisters and scales, which

are subsequently removed by erosive agents or by generation of stresses due to salt crystallisation within the pores of the stones.

The action of air pollutants is undoubtedly increased by the typical street configuration of the urban centre, with very narrow and sheltered streets with intensive car traffic and high rising damp in walls. This favours a long-term effect of the sulphuric acid on the stones.

It is clear that some of the most outstanding monuments of Seville, Spain are seriously damaged and cleaning, consolidation and protection work is urgently needed. Unfortunately, this work is only being carried out on the Giralda, but the Cathedral and the City Hall, which show higher weathering rates seem not to be included among the Spanish monuments to be restored in the near future.

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Figure 1. Gypsum crust of the Giralda. x50

Figure 2. Detail of figure 1. x2100

Figure 3. Gypsum crystal growth. Crust of the Giralda x400

Figure 4. Detail of figure 3. x1600

Figure 5. Gypsum crust of the Cathedral. x800

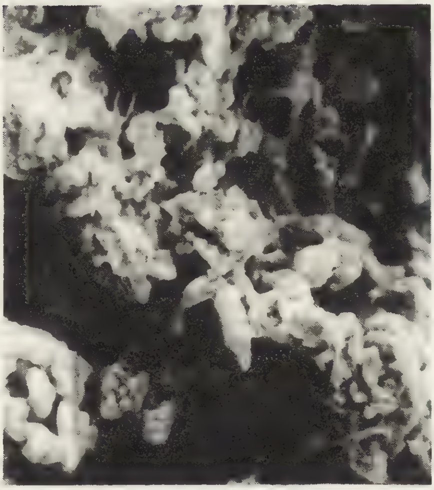

Figure 6. Gypsum and fungal hyphae. Crust of the Cathedral. x400

Figure 7. Gypsum crust of the City Hall. x1500

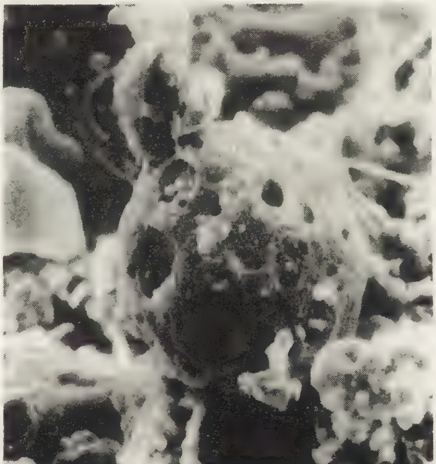

Figure 8. Airborne carbon particle. x1800

81/10/6

PERFLUOROPOLYETHERS AS WATER REPELLENTS FOR THE PROTECTION OF STONE

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Ugo Matteoli, Franco Piacenti and
Piero Tiano

ICOM Committee for Conservation
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Working Group: Stone

PERFLUOROPOLYETHERS AS WATER REPELLENTS FOR THE PROTECTION OF STONE

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Summary

Perfluoropolyethers having molecular weight from 600 to 7000 have been tested in view of their use as water repellents to be applied on stone. They are in fact colourless, chemically stable, permeable to oxygen, nitrogen and water vapour, insoluble in water and common organic solvents but soluble in fluorocarbons, thus providing a reversible treatment. When sprayed on the surface of the stone perfluoropolyethers having molecular weight 6000 - 7000 have provided the best results by reducing the water penetration by two thirds.

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At the Third International Symposium on the Deterioration and Preservation of Stones in 1979* we reported that perfluoropolyethers possess all the necessary requirements to be used as protective agents of works of art in stone.

These products in fact, when applied on stone reduce considerably the rate of absorption of water and the surface humidity.

They are stable: they do not react with stone or oxygen and are not decomposed by ultraviolet radiations. They are moreover colorless, transparent, soluble in fluorinated solvents, insoluble in water or usual organic solvents, are permeable to gases such as oxygen, nitrogen and water vapour. This last property is very important because the stone once treated must still release as vapour the water eventually adsorbed.

They can be removed whenever desired providing reversibility of the treatment.

We wish now to report the results of our latest experiments made to detect the most effective of the available perfluoropolyethers and the best method for its application on Pietra Serena, which is one of the most important stones used in Florentine historic buildings.

The perfluoropolyethers Fomblin YR, Y45, DO we have used have the same chemical structure which is reported below. The only difference among them lies in their average molecular weight (Table 1). Fomblin K has a higher O/C ratio.

$$-(O-\underset{\displaystyle CF_3}{\underset{|}{C}}F-CF_2)_n-(O-CF_2)_m-$$

The products to be tested (Table 1) were sprayed, by a normal compressed air sprayer (3 atm), onto the surface of a series of samples (10x10x0.6 cm) placed at a distance of 30 cm from the spout.

Each product was applied on five samples.

Table 1

Code number of samples of Pietra Serena treated with solutions of perfluoropolyethers in Algofrene 113 at various concentrations.

Code number	Water repellent		
		Molecular weight	Conc. %
FY0	Fomblin YR	6000 - 7000	100
FY1	Fomblin YR	6000 - 7000	75
FY2	Fomblin YR	6000 - 7000	50
FY3	Fomblin YR	6000 - 7000	25
FA	Fomblin Y45	4000 - 4500	50
FD	Fomblin DO	600	100
FK	Fomblin K	n.d.	50
U	Untreated sample	-	-

In all cases the amount of perfluoropolyether applied was 85 ± 5 g/m^2 of stone.

Algofrene 113: Trichlorotrifluoroethane.

The efficiency of the treatment was determined by two tests:

a) Water penetration;

b) Contact angle of a small drop of water placed onto the surface of the stone.

The water penetration was determined by using the device shown in Figure 1 which is an improved version of the one we have previously reported. The pipet was kept pressed against the surface of the stone and the water seal was realized by an O-ring. Readings were done at various time intervals and the data were reported as microliters of water penetrated per cm^2 of surface.

The contact angle of a drop of water (5 microliter) placed on the surface of the stone was measured 10 and 20 seconds after the deposition of the drop. A close up colour photograph was taken at the proper time and the angle between the drop and the surface of the stone was measured on it (Figure 2). This test however gives inaccurate results if the surface of the stone absorbs water and the volume of the drop examined varies. Its accuracy is higher, the higher the efficiency of the treatment with the water repellent because in such a case the contact angle may be measured in near ideal conditions. This test gives an indication of the degree of water repulsion reached by the stone surface.

Results

The same amount (about 80-90 g/m^2) of all perfluoropolyethers was applied on the surface of the stone.

Fomblin YR and Y45 were the most effective of the products tested in limiting the uptake of water: the water penetra-

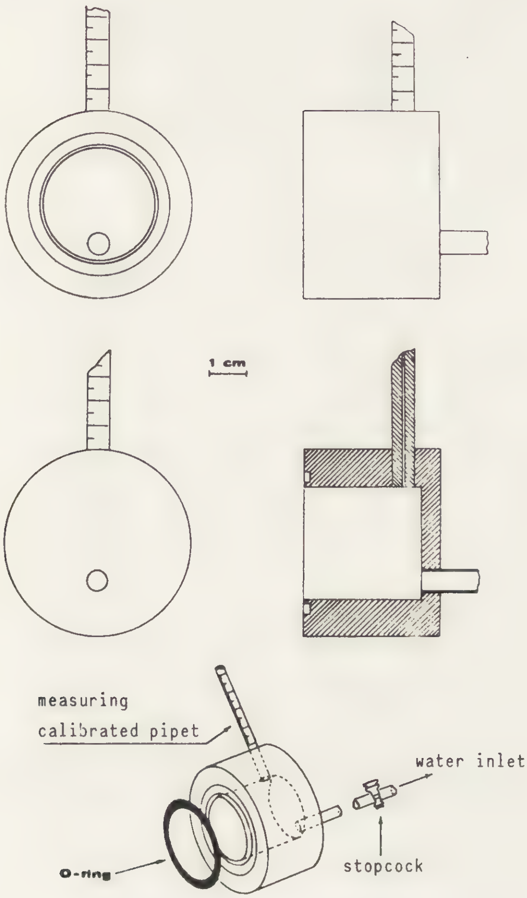

Figure 1: - Device used to determine the water penetration.

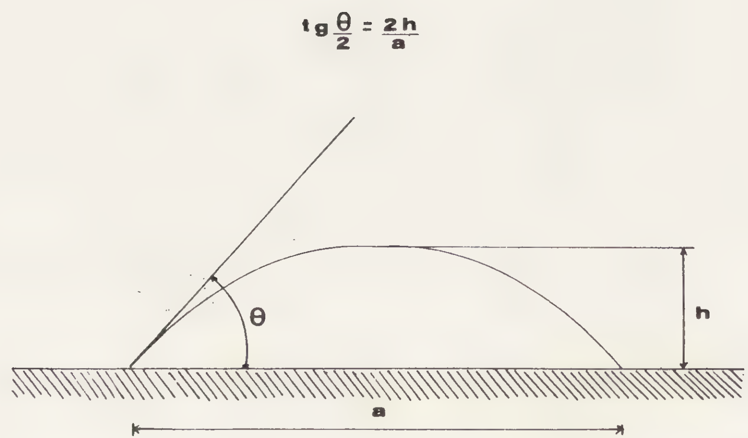

Figure 2: - Method of measure of the contact angle.

tion was in fact reduced by two thirds by such a treatment if compared with that one of an untreated sample (Table 2 and Figure 3).

A very good contact angle was obtained when using Fomblin YR (FY2).

On the basis of these data Fomblin YR appeared as the most promising of the perfluoropolyethers tested.

We have therefore started an investigation to determine how the efficiency of the treatment is influenced by the concentration of the solution of Fomblin YR in Algofrene 113 used for spraying the surface of the stone.

The pure liquid as well as 25%, 50% and 75% solutions were used (Table 3 and Figure 4). The water uptake was reduced by approximately two thirds in all cases.

Better results however, put in evidence specially by the contact angle between a drop of water and the surface of the stone, were obtained when using 50 - 75% solutions. Samples treated with the pure liquid by no means provided the best results. This anomalous behaviour may probably be caused by the high viscosity of the pure product which does not allow the formation of an homogeneous layer of the water repellent on the surface of the stone.

Discussion

A higher activity in limiting water uptake has been shown by the high molecular weight perfluoropolyethers (Fomblin YR and Y45) and among them Fomblin YR provided the best results.

Fomblin Y45 which has a lower molecular weight than YR and a lower viscosity probably penetrates more rapidly and

Table 2

Water penetration data (microliter of water/cm^2 of stone surface) and water contact angles measured at various time intervals on samples of Pietra Serena treated with water repellents.

Code number [a]	Water penetration after time (minutes):					Contact angle after time (seconds):	
	10	15	20	25	30	10	20
FY2	2.5	4.3	5.8	7.1	8.3	63	56
FA	2.1	3.9	5.5	7.0	8.5	20	17
FD	4.0	7.6	10.8	13.7	16.5	13	-
FK	4.3	8.0	11.5	14.7	17.7	26	24
U	6.8	12.4	17.4	22.0	27.0	9	-

a) See Table 1.

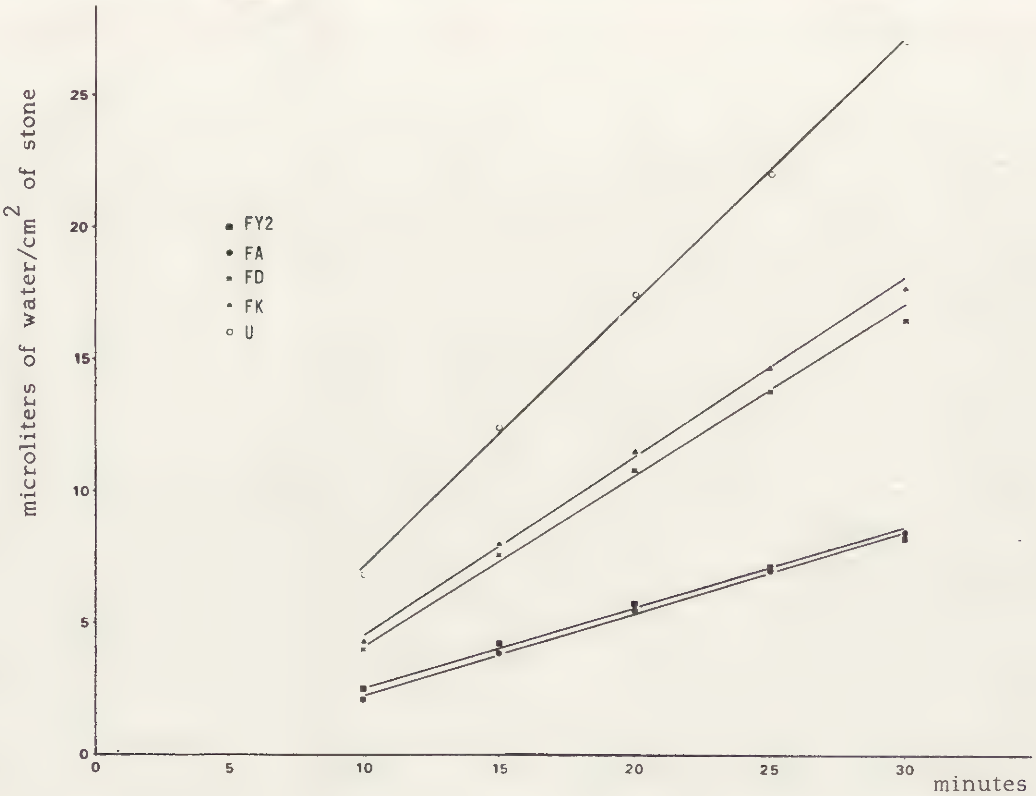

Figure 3: - Curve of water penetration determined on samples of Pietra Serena treated with water repellents.

Table 3

Water penetration data (microliter of water/cm^2 of stone surface) and water contact angles measured at various time intervals on samples of Pietra Serena treated with solutions of Fomblin YR in Algofrene 113 at various dilutions.

Code number[a]	Water penetration after time (minutes):					Contact angle after time (seconds):	
	10	15	20	25	30	10	20
FY0	2.4	4.4	6.3	8.1	9.8	38	32
FY1	2.3	3.9	5.3	6.5	8.2	57	50
FY2	2.5	4.3	5.8	7.1	8.3	63	56
FY3	2.1	4.0	5.8	7.5	9.2	61	56
U	6.8	12.4	17.4	22.0	27.0	9	-

a) See Table 1.

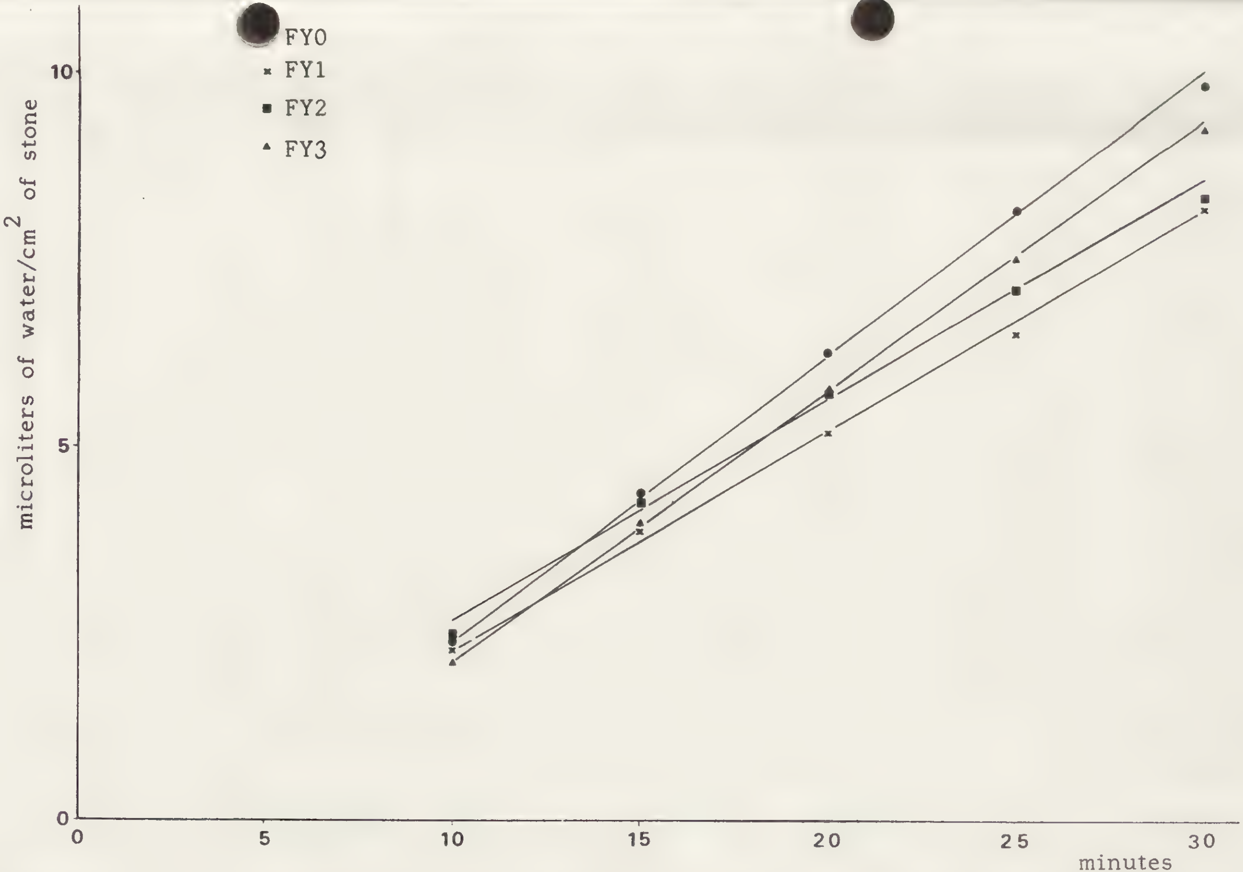

Figure 4: - Curve of water penetration determined on samples of Pietra Serena treated with solutions of Fomblin YR in Algofrene at various dilutions.

deeply in the stone. The amount of product present on the surface at the moment of the contact angle and water penetration determinations is therefore lower in the case of Fomblin Y45 than when using Fomblin YR.

Samples FY1, FY2 and FY3 have given approximately the same results. Fomblin YR in fluorocarbon solution in 25 - 75% concentration may be applied to a surface of stone by air compressed sprayer obtaining a homogeneous thin layer.

On the basis of these results we have decided to use in our subsequent experiments Fomblin YR in 75% solution in Algofrene. While providing a sufficient fluidification of the perfluoropolyether, such a low quantity of solvent limits the atmospheric pollution, reduces costs and working time.

Further work is in progress to verify the durability of the treatment both by natural and accelerated ageing in a climatic chamber.

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81/10/7

UTILISATION DES POLYMERES POUR LA RESTAURATION DES SCULPTURES EN PIERRE DANS LE MUSEE DE L'ERMITAGE D'ETAT

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Comité pour la conservation de l'ICOM
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Groupe de travail: Matériaux pierreux

UTILISATION DES POLYMERES POUR LA RESTAURATION DES SCULPTURES EN PIERRE DANS LE MUSEE DE L'ERMITAGE D'ETAT

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Résumé

Les plusieurs années que les polymères ont été utilisés pour la conservation et la restauration des sculptures en pierre ont finalement détermine les principales exigences auxquelles doivent répondre les matériaux polymères de restauration et les méthodes de leur utilisation.

En qualité de matériaux pour différents processus de restauration le Laboratoire de conservation de pierres et de restauration de sculptures de l'Ermitage d'Etat utilisent des polymères de différentes classes: consolidation de la pierre détruite à profondeur - le polybutylméthacrylate; protection des agents atmosphériques des sculptures en marbre se trouvant en plein air - la cire polyéthylène; élimination de la saleté - le sel sodique de la carboxyméthylcellulose; collage des fragments et masticage des joints, reproduction des fragments perdus - les polymères acrylique et vinylique, résines époxydes et polyéthérées; préparation de moules - caoutchoucs de silicone et polyuréthane.

Grâce au progrès de la chimie et de la technologie des polymères les restaurateurs d'aujourd'hui ont le choix des polymères a un large diapason de propriétés pour la conservation et la restauration d'oeuvres d'art.

On utilise les polymères pour la restaurations des oeuvres d'art en tant que colles, liants, vernis pour la consolidation profonde des matériaux poreux, sujets à la détérioration, ainsi que pour la création des fragments de sculptures.

Cependant malgré le grand nombre de polymères produits par l'industrie et créés dans les laboratoires des Instituts de recherches il n'y en a que très peu qui puissent être utilisés dans la restauration. Cela s'explique par le fait que les spécialistes dans le domaine de restauration réclament des matériaux qui donnent la garantie de sécurité des contacts avec le monument durant une longue période de temps.

Ces exigences avaient été exposées depuis longtemps et à maintes reprises, cependant elles n'avaient pas été assez fondées et n'embrassaient pas tous les problèmes, c'est pourquoi nous trouvons nécessaire de les répeter.

Les polymères choisis doivent avoir les propriétés suivantes:

I. Incoloration.

2. Transparence.

3. Résistance à la lumière.

4. Inertie chimique - absence dans le polymère de groupes pouvant réagir sur le matériau du monument et de même de groupes qui peuvent apparaître dans le composé polymère durant le contact avec le matériau du monument.

5. Solubilité dans les solvants relativement peu toxiques.

6. Propriétés adhésives assurant une jonction durable avec le matériau de l'objet ayant le minimum de contraction du polymère après l'élimination du solvant.

7. Maintien d'une jonction solide avec le matériau de l'objet à condition de conservation à long terme. Dans les conditions de changement de température et de l'humidité ambiante l'objet restauré ne doit pas avoir de craquelures et d'écaillement.

8. Le polymère (colle, pellicule de vernis, pellicule dans les tubes capillaires de systèmes poreux) ne doit pas détruire le matériau du monument.

9. En utilisant les polymères il faut toujours avoir la possibilité de les éliminer, c'est-à-dire que le processus de restauration doit être réversible.

IO. La masse moléculaire qui donne la possibilité d'obtenir différentes concentrations des solutions du

polymère nécessaire pendant différents processus de restauration.

II. Stabilité envers les microorganismes.

I2. Influence minimum sur l'aspect extérieur de l'objet.

Les propriétés physiques et chimiques des polymères sont déterminées, comme on le sait, par la longueur de la macrochaîne (masse moléculaire), par la nature chimique des groupes collatéraux des monomères (interaction dans la chaîne) en cas de polymères à chaînes carboniques, par la nature chimique de liaison et par les atomes qui prennent part à la création de ces liaisons en cas de polymères hétéro-chaînes.

Pour certifier la conformité des polymères aux exigences réclamées on procède à l'Ermitage aux vieillissements à la lumière, à la chaleur et à l'humidité d'après les standards adoptés pour les polymères (on soumet au vieillissement les pellicules détachées du matériau ou avec le matériau sur lequel elles sont appliquées).

Au Laboratoire de conservation de pierres et de restauration de sculptures on emploie pour différents procédés de restauration certains polymères de production sovietique de la série acrylique et vinylique, des éthers de cellulose, des polymères et des oligomères. Ils repondent dans une grande mesure aux exigences énumérées ci-dessus, leur sûreté est vérifiée sur des échantillons pris comme modèles.

Pour la consolidation des pierres qui ont subi des destructions on emploie les solutions de polybutylméthacrylate à basse viscosité (PBMA-BV) dans du xylol ou dans le mélange alcool-xylol. On introduit les solutions dans les pores de la pierre en procédant à l'immersion totale ou partielle, ou bien en appliquant les solutions à plusieurs reprises sur la surface. La concentration des solutions augmente graduellement de 5 à 25% ensuite diminue suivant la capacité d'absorbtion de la pierre. La vaporisation du solvant se fait au ralenti en limitant l'accès de l'air.

Les recherches poursuivies et les résultats pratiques de notre travail ont prouvé que la solidité augmente et la dégradation de la pierre s'arrête si on injecte un polymère de 2 à 3% dans les pores. L'échange d'air et d'humidité s'approchent aux indices d'une pierre ordinaire intacte. La vérification de l'efficacité de la consolidation du calcaire avec les solutions PBMA-BV suivant le régime établi d'impregnation-séchage a montré que le polymère s'est distribué régulièrement dans les pores de la pierre.

Au cours des dernières 25 années à l'Ermitage ont été consolidées avec la solution PBMA-BV environ cent différentes sculptures. Parmi ces sculptures il y des sculptures antiques, de l'Europe occidentale, de l'ancien Egypte, des sculptures coptes, des statuettes et des reliefs en calcaire de la ville de Palmyre, des statuetten en grès de l'Inde et de l'Indonésie etc. Des examens périodiques témoignent du bon état de leur traitement. Le procédé qui a pour but de faire sortir les sels hydrosolubles des pores de la pierre prouve que notre méthode d'imprégnation ne bloque pas les sels qui se trouvent dans la pierre et après la consolidation ils sont extraits avec l'eau. Les épreuves ayant en vue d'éliminer les solutions PBMA des pores de la pierre consolidée prouvent qu'on peut les dissoudre et éliminer le polymère I5-20 ans après.

En consolidant la pierre se trouvant à l'air libre avec les solutions PBMA il est nécessaire de procéder à la hydrofugation de la surface. Les sculptures du Jardin suspendu du Petit Ermitage sont reciuvertes d'une mince couche de cire de polyéthylène qui protège bien le marbre durant 3-4 années. Une pratique pareille au cours de 8 ans a donné de bon résultats.

Les sculptures conservées au musée doivent aussi être protégées de poussière et de suie qui pénètrent dans les pores. Les dernières années nous élaborons des compositions de polymères solubles dans l'alcool et dans l'eau qui forment une pellicule protectrice facilement enlevée avec de l'eau ou avec le mélange d'eau et d'alcool.

Pour le décrassage des sculptures en pierre nous utilisons la solution aqueuse de I5-2I% du sel de sodium de carboxy methyl cellulose (KMЦ) plastifiée de glycérine. Les dernières 2-3 années des dizaines de sculptures en gypse, en terre cuite, en calcaire et en marbre ont été nettoyées de crasse suivant cette méthode au Laboratoire de conservation de pierres et de restauration de sculptures. Surtout ce procédé est effectif en nettoyant le gypse ou une pierre fragile quand l'action de l'eau et le frottement en grande quantité sont inadmissibles.

Actuellement nous cherchons la possibilité d'utiliser d'autres polymères solubles dans des solvants organiques qui peuvent éliminer les taches de graisse, de vernis et de cire. Une des recettes pareilles est connue, c'est celle de Plenderleith, cependant l'utilisation de la nitrocellulose recommandée doit être limitée dans le musée à cause de son inflammabilité et de la toxité des solvants c'est pourquoi elle devrait

être remplacée par d'autres polymères.

Pour coller les fragments d'une sculpture en pierre nous utilisons les solutions de PBMA-HV (haute viscosité) dans de l'acétone, de polyvinylacetate (PVA) ou de polyvinylbutyral dans de l'alcool. Dans les cas quand le collage doit être extrêmemant durable nous employons la résine époxyde (ЭА - 20) ou la résine polyster (ПН -I).

Pour remplir les petites lacunes de la surface (creux, craquelures, joints de collage) nous utilisons les mêmes réactifs employés lors du collage dans un mélange avec un remplissage (pierre broyée, pigments). En outre on utilise comme liant pour préparer un mastic la matière fondue des résines thermoplastiques.

Pour la reproduction des parties perdues on utilise des masses à mouler et des mélanges de pierre broiyée et de liants à base de polymères synthétiques. La préparation de formes élastiques avec le minimum de joints se fait avec le formoplaste ou bien avec un caoutchouc synthétique qui rendent avec beaucoup d'exactitude non seulement la forme mais aussi sa facture du détail reproduit de la sculpture. Le formoplaste c'est le fondu du mélange de la résine de polyvinylchlorure plastifiée de phtalate de butyle en ajoutant du stéarate de calcium; le formoplaste fond à la t° de 200°C sur un bain de sable dans une hotte a condition de remuer constamment. Il est beaucoup plus facile de travailler avec un caoutchouc de silicone bas-moléculaire du type (Compaund de Leningrad) qui durcit à la température ambiante et auquel on ajoute un catalysateur et un plastifiant. La masse durcie donne une forme solide et souple qui peut être coulée des masses de polymères sans couche disjonctice. Dans les cas ou la solidité doit être excessive nous créons la forme du caoutchouc de polyuréthane.

Pour reproduire les détails perdus des sculptures en pierre on remplit les moules de compositions à base de monomères ou d'oligomères. Dans la combinaison avec un remplissage ils créent une masse qui imité la pierre naturelle. Les monomères - méthylméthacrylate ou butylméthacrylate - s'emploient dans le mélange avec du polyméthyl - ou polybutylméthacrylate pour amoindrir le retrait. Si on ajoute un initiateur et un catalyseur le compound peut se polymériser sans être réchauffé et sans être irradié.

Parmi les liants oligomériques nous employons aussi les résines époxides et polyesters pour imiter la pierre. On broie les pierres en les soumettant au traitement thermique ce qui désagrège le marbre en cristaux. Du mélange de cette pierre broyée avec des pigments et

des liants on reçoit une pierre naturelle (marbre, calcaire, albâtre, grès et d'autres). La reproduction d'espèces claires s'effectue avec des polymères acryliques résistant à la lumière. Le besoin de suppléer les déteriorations des sculptures se trouvant à l'air libre exige l'emploi du polyester résistant à différentes conditions atmosphériques.

Au Laboratoire de conservation de pierres et de restauration de sculptures au cours de restauration de toute une série d'objets en pierre on a suppléé les détails qui manquaient avec des masses similaires à base de polymères (portraits romains en marbre, vase en albâtre, reliefs en calcaire etc). Quelques uns des suppléments ont changé de nuance avec le temps, mais ce n'étaient que des changements insignifiants. La qualité des suppléments et leur bon état de conservation durant le processus de vieillissement est détarminé par la pureté des polymères employés et l'exactitude des doses des durcisseurs ainsi que d'autres composants. Nous tâchons d'utiliser les matériaux des firmes de notre pays qui peuvent garantir la qualité stable des réactifs.

L'utilisation des polymères ouvre devant les restaurateurs d'aujord'hui de nouvelles possibilités dans la réalisation de beaucoup de processus de restauration élevant l'efficacité des méthodes et perfectionnant la qualité du travail.

81/10/8

TREATMENT OF WHITE MARBLE BY SILANES FOR CONSERVATION PURPOSES

E.G.Mavroyannakis

ICOM Committee for Conservation
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Working Group: Stone

TREATMENT OF WHITE MARBLE BY SILANES FOR CONSERVATION PURPOSES

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Abstract

White marble has been used in the past for many purposes,because of its composition it is however easily attacked by pollution products like sulfur dioxide,undergoing transformation into gypsum. Deterioration becomes therefore very fast and important works of art undergo degradation. In this paper,we present results of treatement by silanes as well as our observations on the ageing of this marble.Due to the satisfactory behavior of the marble after treatement, it seems that silanes can be considerated suitable for preservation purposes of ancient works of art .

Introduction

White marble is an important material composed mainly of calcite, but it contains also small amounts of silicon dioxide and other impurities /I/. The function of any treatement of this marble is (a) to delay transformation of calcite into gypsum, as a result of SO_2 attack, (b) to delay decay mechanisms, as crystallization of ice and (c) to redistribute stresses of various origin more safely than before treatement. Any treatement which improves properties of the marble making it less vulnerable without changes of its appearance, is worth considering .

Since I972 we are performing experiments on the consolidation of materials including marble. We have prevalently applied consolidation :

a- by radiopolymerisation of synthetic monomers,

and b- by hydrolysis of silanes .

It seems that consolidation by silanes is a very effective process for marble and coatings are formed easily. On the other hand synthetic monomers have serious problems for white marble in comparison to silanes .

The silanes method has already been applied for stone consolidation with promising results /2//3//4/. We have used two different silane monomers supplied by Wacker Chemie as one-pack system, under the commercial name Wacker Sandstone Strengthener Agent OH and H respectively. Agent H contains hydrophobic components, whereas Agent OH offers reinforcing properties only . These monomers crosslink in presence of atmospheric humidity, requiring time of exposure between I00 and I20h and leaving SiO_2 as a product of hydrolysis. Into the marble pores silicon dioxide bonds with quartz grains, providing strength to the matrix material improving durability. The protective coating formed on the surface prevent moisture penetrating into material.

It is expected that marble must be less vulnerable after treatement, depending however on the coating characteristics : thickness, thermal properties and stability, durability, cracks etc.

Method of Treatement

A number of white marble pieces of dimensions 40X30X5 mm has initially been impregnated with H and OH agents, by immersion for 24h under ambient conditions (29 C and 35o/o RH). As white marble used is pendelic, it is very compact with very small porosity. Penetration of liquids during impregnation is difficult involving a thin layer only of the marble. After hydrolysis only 0,2o/o of silicon dioxide has been found to remain on the surface layer. After a second impregnation for 24h no increase of weight has been found. The layer of silicon dioxide formed on the surface does not change the appearance of the marble, moreover appreciable change of contact angle has not been found. Accelerated ageing under sunlight conditions for 46 days, corresponding approximately to two years exposure under sunlight, does not reveal any alteration. At this moment attack by dilute sulfuric acid is under study .

For deteriorated marbles a layer of gypsum grains covers the surfacewhich can easily be removed or washed out by the rain . In this way new grains are formed on the surface and deterioration proceeds in depth. The detariorated marble becomes more porous and higher quantity of silicon dioxide can be retained. In this case treatement must be more effective than in frashly formed surfaces, the coating thickness extends up to the compact marble and it must be thicker for the more deteriorated material .

Treatement of Ancient Marble

The main purpose of our work was the consolidation of deteriorated surfaces of ancient white marble. By filling up all void spaces with silicon dioxide the following advantages are obtained regarding degradation :

(a) the deteriorated material is strengthened
and (b) the intact material is shielded because of the coating action .

In this way delay of ageing mechanisms must be obtained for more efficient surface layers .

We have impregnated a number of big pieces of ancient marble with Agent H,and exposed them to free atmospheric conditions at the Byzantine Museum of Athens,which is a very polluted city area . These marbles were in advanced conditions of deterioration. Impregnation was performed by spray gun of low pressure and by brushing. The spray gun technique is simpler and gypsum grains are not necessarily removed. On the other hand brushing technique is more effective but grains of gypsum are removed which behave as a filler for silicon dioxide.

After consolidation the result was excelent and no esthetic alterations were observed. After a second impregnation the gypsum grainswere strongly attached on the surface,and it was quite impossible to remove them when rubbed hard with finger tip. Afterthat impregnation of a second butch of marble has been carried out .Two ancient columns exposed in the courtyard of the Byzantine Museum have been treated by brush,with the same result as mentioned above.

All marbles treated are exposed for two years, at the moment of writing this paper,under free atmospheric conditions without any sign of decay or formation of gypsum grains, although parts of columns left untreated continue to decay.It seems clearly that deterioration is at least restricted in regions of small extension,or it proceeds with a very small rate, giving imperceptible alterations. Although the degradation period is not at all long,it is possible to repeat impregnation if necessary for further protection of the marble. It has also been observed that treated material is less dirty than untreated and cleaning is easier . It is however too early to draw definite conclusions on the weathering behavior and durability of the silicon oxide coating,as well as on the real value of preservation offered by silanes on white marble. It seems that the treatement technique applied is suitable,as deterioration in our climatic conditions is mainly due to chemical attack and thermal degradation,while freezing is a less common process in many parts of our Country.

In otherclimatic conditions it may be necessary to repeat the treatement many more times as proposed by Moncrief /4/.

Concluding Remarks

Consolidation of white marble with silanes is a very simple,effective,coherent and non trivial method,without serious limitations from the point of view of the piece dimensions to be treated,or the safe repetition of the impregnation. All these advantages egree that much efforts are stll needed in order to study the weathering laws of the treate material,by performing more systematic research and observations for longer periods of time. In this way the fine structure of physical,chemical,biological and petrographic processes,which govern weathering,will be discovered and improved solutions will be found,suitable for conservation purposes of the marble.

Acknowledgements : The author is indebted to Mr A Baltoyannis of the Byzantine Museum of Athens as well as to Mr A Antonopoulos and A Kokkinos for their assistance .

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81/10/9

SPECIFIC FEATURES OF MORTARS IN THE ANCIENT RUINS OF CISTERNS AND BATH IN ALEXANDRIA, EGYPT

Barbara Penkala and Ewa Bralewska

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SPECIFIC FEATURES OF MORTARS IN THE ANCIENT RUINS OF CISTERNS AND BATH IN ALEXANDRIA, EGYPT

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Summary

This paper contains results of tests of samples of mortar picked up in antique objects, which date back to 2nd and 3rd century A.D., i.e. Kom el-Dikka complex in Alexandria. As the tests have proved, the types of mortar there are very specific due to uncrystallized silica which over-saturates the samples. Silica is thought to be introduced purposefully to the mortars because of the specific character of the objects where the least penetrability is desired. The condition of the mortars, in spite of their exposure to water and after so many centuries, is still good due to their relatively high compressive strength.

1. Introduction

The survey included bricks and mortars from the baths and cisterns in the antique complex Kom el-Dikka in Alexandria /1/ which was discovered by a group of archeologists led by Prof.K.Michałowski in the years 1966--67. Drawing 1 shows a situational plan of the objects from which eng.Jan Borkowski took the samples in the year 1978. They were needed for a report about the state of preservation of the antique complex for the Egyptian Government and Polish Station of Mediterranean Archeology in Cairo. Both objects, the baths and the cisterns, were made of ceramic bricks joint with mortar. In the baths, thin bricks were joint with layers of mortar 6 cms. thick. Thus built wall was covered with a layer of plaster 10 cms. thick. The cisterns were built of thick bricks and joint with thin layers of mortar; the walls were not plastered.

2. Results of tests on ceramic bricks

Ceramic bricks of the walls are reddish - tawn and red in colour. In some of them there is vegetable filler

in the form of a chaff. The specific gravity of the bricks is 1,39 to 1,54 gms/ccm, porosity 36,1 to 44,4 per cent and imbibeity 24,9 to 26,2 per cent. Their compressive re-strength varies from 2,7 to 16,5 MPa. The difference in the degree of resistance results mainly from the heterogeneity of their structure and not so much from the degree of their destruction as all tested samples exhibited satisfactory state of preservation. The salinity of the bricks in both objects is quite high; they contain 1,3 to 3,2 per cent of soluble salts. Among the soluble salts are: sodium, calcium and magnesium sulphates and chlorides.

3. Results of the tests on mortar samples.

3.1. Physico-mechanical properties of the mortars.

The samples of mortars from the baths and cisterns show similarities in respect of their physico-mechanical properties and compactness. The specific gravity of the samples from the baths is 1,23 gms/ccm. and from the cisterns - 1,25 gms/ccms; porosity is very high and amounts to 53,03 and 51,17 per cent, respectively; imbibeability - 34,7 and 34,8 per cent which indicates existance of a big number of open pores. The compressive strength is relatively high and ranges from 2,6 and 3,6 MPa for the samples from the baths and from 2,5 to 3,0 MPa for the samples from the cisterns.

3.2. Results of the chemical analysis of the mortar samples.

The chemical analysis of both types of mortar showed considerable similarities. The baths samples showed contents of 35,5 per cent of parts insoluble in hydrochloric acid; whereas the samples from the cisterns - 46,7 per cent. The contents of salts soluble in water reached 9,6 per cent in the samples from the baths whereas 7,3 to 11,2 per cent in the samples from the cisterns. The qualitative analysis showed the existence of the following ions: K^+, Na^+, Ca^{+2}, Mg^{+2}, Cl^-, NO_3^- and SO_4^{-2}; there appeared slight quantitative differences which depended on the object the samples came from. Potassium dominates in the samples from the cisterns; magnesium - in the samples from the baths. Nitrates appear solcly in the samples from the cisterns. As far as sulphates, there are double more of them in the samples from the cisterns than in those from the baths. Their contents amounts to 0,6 per cent, which in terms of gypsum means 1,1 per cent for the cistern samples, and 0,25 per cent which equals to 0,5 per cent of gypsum for the samples from the baths. Taking away sulphates, the content of salt amounts to 9,1 per cent for the samples from the baths, and 6,2 to 10,1 per cent for the samples from the cisterns. The ionic content of soluble salts indicates that apart from sulphates there are mainly sodium - or potassium - chlorides and carbonates. The salts found in the bricks of the walls have si-

milar content. The amount of silica soluble in water is very small as it only about 0,1 per cent in both samples. The total content of silica in the binder estimated by the molibdenian method is 11,5 per cent in the samples from the baths and 10,9 per cent in the samples from the cisterns

3.3. Mineralogical analysis of the mortars.

The samples of the mortar from the baths and the cisterns are small-pored, relatively compact, their colour being greish-pink. Microscopic analysis of thin sections in the passing light showed that these are limy-siliceous mortars containing ceramic filler with slight addition of carbonate rock and quartz.

Mortars from the baths contain filler which consists of about 30 per cent of grains of red ceramics, grains of carbonate rock and small quantity /about 5 per cent/ of quartz and feldspar. Small chips of gypsum rock whose structure is fibrous appear in isolated cases.

Filler. The dimensions of the fragments of red ceramics are between 0,05 and 5,00 mms., seldom reach 12 mms. Individual grains of the ceramics are brick - red or tawny red; usually roundish, seldom sharp - edged. They are made of ceramal, ferruginous, slightly anisotropic, partly micro - crystalline and partly vitreous substance - the latter indicating low temperature of their burning. In this substance there are also sharp - edged grains of quartz, feldspar and, very scarce, plates of mica. Only few grains of ceramics contain mullite which points to high temperature of burning of the element from which the fragments have been taken. The size of the grains of quartz and feldspar as well as their quantity differs in each chip of the ceramics. The ceramic filler comes most probably from the brick rubble which was present during the erection of the walls of the baths.
The dimensions of pores in the ceramic grains vary from 0,05 to 1,5 mms; their shape is either oval or irregular. Some of the pores do not contain any filler.
The rest contains uncrystallized silica which forms stratified incrustations sometimes accompanied by fine crystalline gypsum and calcite in the form of crowns. In some places, in the pores can be seen chlorides enclosed by calcite or silica. The way in which silica appears points to its diffusion, in the form of colloidal solution, from the mortar into the grains of ceramics.

Grains of quartz which act as filler in the mortar are considerably well rounded, markedly cracked, and are characterized by fluent dispersing of light. Their dimensions vary from 0,05 to 0,3 mms. There are also sharp - edged grains whose size is from 0,001 to 0,05 mms. The rounded grains of quartz are corroded on the surface and in thus formed shallow bites carbonates have been crystallized.

The dimensions of carbonate grains which make the filler vary from 0,05 to 1,02 mms. The grains which reach 15 mms in diametre are scarce. Carbonate chips make two types of rocks, i.e.: oöidic limestone with aragonitic oöids and medium - and coarse - crystalline calcite binder, and fragments of coral - ligenous limestone with well - preserved organogenetic remnants. In the mortar there are also present single oöids, the corals and medium - grain - calcite aggregates. It seems that some of the small carbonate grains might be the result of an inadequate lime-burning.

The calcite - siliceous mortar substance contains many diffuse fragments of carbonized organic substance of longish shape with the image of vegetable cells which are sometimes filled with fine - grained gypsum or calcite. These vegetable cells are believed to be the remains from the process of lime - burning.

The binder.

The mortar contains lime - siliceous binder. Calcite produced in the process of hardening makes a fine - crystalline substance which fills quite vast areas. The carbonates of the binder crystallize locally into medium - crystalline aggregates; they are particularly numerous on the rims of the grains of the ceramics. Silica appears here in opaline form which is indicated by its low coefficient of refraction of light and the form it occurs. Silica oversaturates porous grains of the filler and the whole substance of the carbonate binder which indicates that it had been added in the form of colloidal solution, together with the mixing water, in the process of making the mortar. The purpose of such procedure was, undoubtedly, to diminish penetrability of the mortar. Similar thing has been done, for example, in Britain where a special siliceous mortar has been worked out; it contains quartz sand, siliceous powder and silicaseal solution with ethyl silicate.

The mortar from the cisterns is much the same as the mortar from the baths in respect of the content of the binder, the way it occurs and the type of the filler.
They differ in a slightly higher content of ceramic filler which amounts to about 40 per cent according to the estimations made by the planimetric method.
The content of the ceramic grains and their structure is similar or identical with the ceramic grains in the samples of the mortar from the baths. In the ceramic pores in the mortar from the cisterns there is much fewer siliceous incrustations but the amount of gypsum and chlorides is higher. There is also calcite. The amount of quartz and feldspar - in the form of the filler is about 5 per cent. The type and the size of carbonate grains are the same as in the samples from the baths but there are fewer

of them. The pores in the binder are small usually oval, and with relatively rare sinter layers of uncrystallized silica and calcite on their rims; on the other hand, however, fine - crystalline gypsum occurs frequently.

4. <u>Conclusions.</u>

- The mortars from the baths and the cisterns are lime--siliceous which results in their relatively high durability and long lasting.
- Carbonate binder is totally carbonatizated and occurs in the form of crystalline calcite.
- Silica occurs in the opaline form oversaturating the whole substance of the samples. The way it occurs indicates that it had been added to the mixing water as a colloidal solution in the process of making the mortar.
- The aim of adding silica to the mortars was to diminish their penetrability due to the character of the object.

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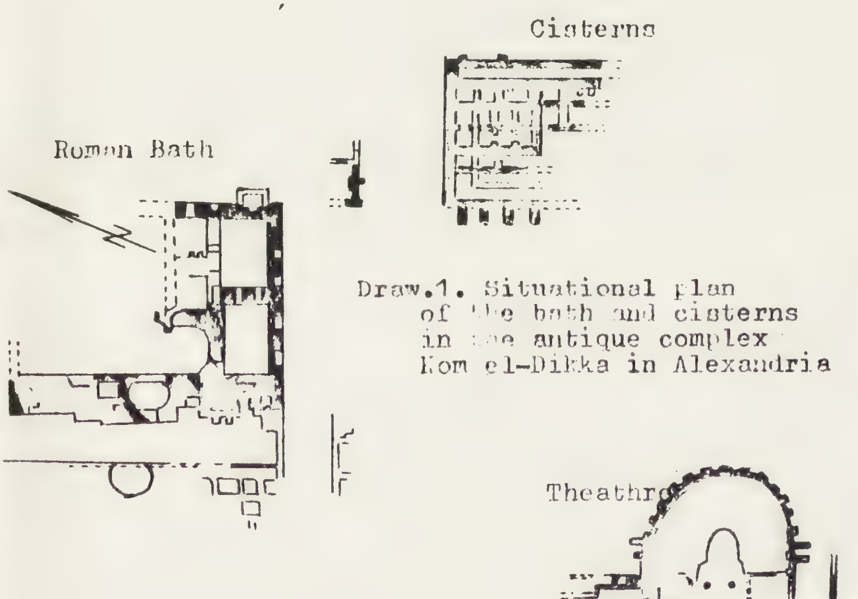

Draw.1. Situational plan of the bath and cisterns in the antique complex Kom el-Dikka in Alexandria

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COMPARATIVE ANALYSIS OF ANTIQUE GYPSUM MORTARS FROM THE WALLS OF THEATRE IN ALEXANDRIA, THE PYRAMID OF CHEOPS AND EARLY-MEDIEVAL WALLS OF THE RELICS AT WISLICA AND GNIEZNO IN POLAND

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Working Group: Stone

COMPARATIVE ANALYSIS OF ANTIQUE GYPSUM MORTARS FROM THE WALLS OF THEATRE IN ALEXANDRIA, THE PYRAMID OF CHEOPS AND EARLY-MEDIEVAL WALLS OF THE RELICS AT WISLICA AND GNIEZNO IN POLAND

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Summary

The report contains results of the tests on gypsum mortars from Egypt and Poland. The comparison of their structure, content and types of their components proves that the technology of their preparation was in both cases similar. The differences are only quantitative. The fact that the mortars from Egypt contain more ceramic filler results from the fact that the Egyptians had already known how to make ceramics which in Poland became known much later.

1. Introduction

The application of gypsum mortars originates from the ancient times. The possibility of their identification is connected with the discoveries and archeological research work. The presence of gypsum binder in the mortars of the internal stone elements has been noticed in such objects as: Pharao's tombs, Egyptian temples, the Pyramids of Cheops, Chefren and Miceren /the years 2900 - 2750 B.C./. The technology of gypsum binder had spread from Egypt to Babilon and Asia Minor, via Greece to Rome and, then, to Europe /1/. In Poland, the presence of gypsum mortar has been discovered in the early-medieval objects at Wiślica /3/, Gniezno /5/, Kije and in the Wawel Castle.

2. Results of the tests on gypsum mortars from the Theatre in Alexandria and the Pyramid of Cheops in Giza.

2.1. Mortar from the Theatre.

The samples were taken from the walls from between the blocks of pale-cream, rather soft ooidic limestone, whose density is 2,85 gms/ccm, specific gravity 1,81÷ ÷ 1,98 gms/ccm, porosity 30,3÷36,7 per cent, imbibeability 15,5÷18,4 per cent. The macroscopic samples of limestone are satisfactorily well preserved, however,

their structure is weaker; this shows in their low and not equal values of their compressive strength which is 6,3÷14,9 MPa.

The tests of the mineralogical content of thin sections in a passing light showed that the mortars are gypsum ones containing ceramic and gypsum filler.

The binder of the mortar is well crystallized. Gypsum which exists in the binder forms a fine-crystalline substance which, especially near the grains of gypsum aggregate, exhibits certain features of an oriented structure. Apart from gypsum, there is also very fine-crystalline calcite which forms a kind of incrustations. In many instances, calcite is accompanied by yellowish-orange iron oxides. Moreover, calcite forms rims around the pores and grains of ceramics. The existence of calcite in the mortar is connected with the presence of small amounts of calcium carbonate in the gypsum rock; in the process of lime-kilning the calcium carbonate had been transformed into lime.

The filler of the mortar consists mainly of roundish grains of slightly burnt limy clay whose dimensions range from 0,07 to 15 mms. They are numerous in the whole substance of the mortar. The kilned clay contains fine aggregates of loamy minerals, a big amount of carbonate pelite /which contains an addition of iron oxides and aragonite/ and a considerable amount of sharp-edged even-grained quartz whose dimensions vary from 0,05 to 0,1 mms. There are also few roundish grains of red ceramics which contain in their sinter, ferrons substance, grains of quartz and feldspar. Occasional carbonate grains traced in the mortar consist of chips of organogenetic pelitic limestone and ooidic limestone. Quartz acting as filler appears occasionally in the form of sharp-edged grains whose dimensions do not exceed 0,2 mms. Numerous fine grains of alabaster rock whose structure is fibrous or feathery act as filler. These grains are often damaged and contain irregular gaps. These empty gaps have been left by the sulphates soluble in water; this assumption can be confirmed by their presence in the pores in the form of rare crystals. Some of the salts are isotropic which can indicate the presence of chlorides of regular structure. The chemical analysis proved that the amount of soluble salts is 6,0÷7,7 per cent. There is also present dolomite in the form of rhombohedral inclusions.

2.2. Mortar from the Pyramid of Cheops.

The sample has been taken from the mortar between a granite facing of the Pyramid and the internal blocks of limestone. The macroscopic sample shows a micro-porous mortar, fairly compact, with a cream-white binder with numerous grains of white alabaster and small number of grains of red ceramics.

On the basis of tests on thin sections in a passing light, it has been noticed that gypsum containing a slight addition of calcite acts as binder in the mortar. The gypsum binder is fibrous and similarly to the samples from the Theatre, has an oriented structure near the grains of alabaster aggregate. In the gypsum binder, there are not big but fairly numerous groupments of iron oxide and rather rare corbonate incrustations.

The filler of the mortar is made of: big grains of gypsum whose structure is fibrous, certain quantity of ceramics and few carbonate and quartz grains. Alabaster filler can be classified in two groups according to the size of its grains, i.e. sand /grains from 0,5 to 5 mms/ and coarse aggregate /grains from 5 to 10 mms/. The grains of alabaster are generally longish. Similarly to the samples from the Theatre, some grains of gypsum are damaged, frayed and contain irregular gaps which are fully or partly filled with salts which amount to 6,3 per cent. Few fragments of ceramics in the mortar do not contain any grains of quartz in their sinter substance. There are, on the other hand, calcite skeletons of microorganisms, this indicates a low temperature of clay-kilning. Occasional grains of carbonate filler are the crumbs of organogenetic limestone containing aragonitic skeletons and shells. Quartz occurs in the form of roundish grains without any cracks or pits. Their dimensions do not exceed 0,5 mms.

Comparing mortars from the Pyramid of Cheops and the Theatre, a conclusion can be drawn that similar technologies had been applied in both cases. The content of both mortars is much the same; the elements are the same and the only differences are due to not equal quantities and material used.

2.3. Mortars from Wiślica.

Gypsum mortars appear at Wiślica in the relics of four ancient complexes of stone objects.

In the church with an apse /6/ built in the 10th century A.D. on the site of a part of a font built in the 9th century A.D. of gypsum stone there is only lime-mortar-very damaged and crumbling. In the walls of an annex to the church, built slighthy later, and in one of the tombstones occurs well-preserved gypsum mortar which contains 50 per cent /in the walls/ and 70 per cent /in the tombstone/ of a very fine-crystalline gypsum binder and ~14 per cent of micro-crystalline carbonate binder. The filler is made of grains of fibrous gypsum 20 and 25 per cent, respectively, crumbs of limestone ~10 per cent, crumbs of ceramics 3,5 per cent, quartz sand 7+10 per cent, whereas 1,5 per cent of the latter in the tombstone.

In the relics of the first and second Romanesque church, discovered in the vaults of the Gothic Collegiate Church at Wiślica, occurs gypsum mortar but in the second church lime-mortar occurs and the gypsum mortar has secondary character because it is bound with the elements from the pulled down walls of the first church. The gypsum mortar in those objects contains 60÷65 per cent of gypsum binder, ~6 per cent of carbonate binder, 25÷33 per cent of the filler consisting of grains of fibrous gypsum, 2÷4 per cent of ceramic crumbs and ~2 per cent of quartz grains. An ornamented floor slab, discovered in the first of the two Romanesque churches, is made of pure gypsum mortar which contains ~40 per cent of gypsum binder, 56 per cent of the filler of fibrous gypsum and 3,5 per cent of ceramic grains. The engravings of the ornament are filled with a black tar substance. The mortar from the grate stoves of an ancient borough is also pure gypsum mortar made up of: 68 per cent of gypsum binder, 30 per cent of fibrous gypsum filler and 2 per cent of quartz grains. In the remains of the foundations of 4 buildings on the site of the Castle /Duke's House, rotunda, second house, and the rotunda with an apse on a plan of octagon/ gypsum, gypsum-lime and lime-mortars occur. The gypsum mortars contain 50÷60 per cent of crystalline gypsum binder, 20÷40 per cent of fibrous gypsum filler, 5÷10 per cent of crumbs of organogenetic limestone, 2÷10 per cent of quartz sand, 2÷5 per cent of ceramic crumbs and 5÷12 per cent of micro-crystalline carbonate binder. Gypsum mortars which are to be found in the flagstones in the courtyard of the "Castle" complex /4/ are very much alike, except for the fact that they contain less gypsum filler and limestone crumbs but more quartz sand /9÷35 per cent/. The lime-gypsum mortars from the rotunda with the apse and the flagstones from the courtyard contain 40÷45 per cent of crystalline gypsum binder, over 15 per cent of micro-crystalline carbonate binder, 5÷10 per cent of limestone crumbs, 5 per cent of ceramic grains and quartz sand. The gypsum filler, however, does not occur. All mortars from Wiślica contain a very small amount of fine black crumbs of under-burnt charcoal. In some samples few grains of another type of gypsum mortar occurs which had most probably been re-applied as filler. The carbonate binder which occurs in gypsum mortars derives from carbonate admixture from gypsum stones used for gypsum-kilning. As the survey of that region has proved, all types of gypsum, except for alabaster varieties, contain calcium carbonate. The crumbs of limestone present in the mortars come from crumbled limestones, same as these in the walls. Quartz sand is the same in all mortars at Wiślica. The structure and content of the grains of cera-

mics are similar and are believed to have come from burning of clay which had been used for coating of the pile for gypsum - kilning. Fibrous gypsum used in mortars as filler is found at Wiślica. The state of preservation of the mortars differs; the indices of compressive strength show striking extremes: 2,2 ÷ 21,1 MPa. Big differences occur also in the degree of their abrasibility on Böhm's disk: 0,46 to 1,29 cms compressive strength of gypsum-lime mortars from the rotunda with the apse amounts to 3,5 ÷ 5,1 MPa. A very high degree of compressive of the well-preserved samples of gypsum mortars point to the fact that their binder had been burnt to gypsum estrich, partly at least. The mortars of low abrasibility contained a bigger quantity of quartz sand.

2.4. Mortars from Gniezno.

Z. Brochwicz's investigations /5/ have proved that gypsum mortar exists in the Romanesque founolations of stone architecture discovered in duke's borough in Gniezno. The gypsum mortar from the oldest part of the foundations contains 49,2 per cent of gypsum binder, 8,4 per cent of carbonate binder, 7,5 per cent of gypsum filler, approx. 2 per cent of ceramic grains and 30 per cent of quartz sand with some crumbs. The feldspar, glauconite and iron - oxides which occur in the mortars do not exceed 3 per cent; they are believed to be the components of sand. Mortars from the later part of the foundations are diverse and the proportions of individual components are enclosed within very broad limits, for example: 50÷60 per cent of gypsum binder, 12 to 20 per cent of carbonate binder, 5÷16,6 per cent of gypsum filler, 7 to 33,7 per cent of quartz sand, 1,5 ÷ 3 per cent of feldspars, glauconite and iron oxides, 0,3 to 0,6 per cent of ceramics and 0,2 to 5 per cent of limestone crumbs.

The mortars from the latest part of the foundations can be described as purely gypsum ones because they contain ~ 75 per cent of gypsum binder and over 18 per cent of gypsum filler. Moreover, there is: ~ 4 per cent of carbonate binder; limestone crumbs occur rarely and there is only 0,4 per cent of ceramic crumbs. Quartz sand together with admixtures amounts to 2,5 per cent.

Small quantities of fine bits of under - burnt charcoal have been found in all fested mortars.

The above discussed gypsum mortars differ in their quantitative composition whereas the components are the same. The amount of ceramic grains is very small which suggests that they come from the clay coating of the gypsum - kilning pile. Presumably, the mortars in the older and the later part of the foundations were made according to the same recipe. The differences resulted only

from individual changes in the dosage of the components. In the latest parts of the foundations the receipe was different. The test of the mortars could, thus, serve as an accessory index estimating age of individual elements in the ancient objects under survey.

3. Recapitulation

The comparison of the results of tests on gypsum mortars from Egypt and Poland shows a high degree of similarity which proves that in both cases the same technology was applied. The components are basically the same; differences occur only in their quantities. However, similar differences manifest themselves in gypsum mortars from individual objects within Poland. It seems, Egyptian gypsum was kilned in a lower temperature due to the application of vegetable fuel and not wood whose calorific value is much higher. Polish mortar contains fine grains of under - burnt charcoal. Taking the above into account, it is very doubtful that estrich gypsum could have been obtained in Egypt; it could have been more likely in Poland. Such statement can be proved by a high degree of compressive strength /21,1 MPa/ of some of the mortars from Wiślica. The existence of well - preserved carbonate organic skeletons in the grains of ceramics in the Egyptian mortars indicates also the relatively low temperature of clay-kilning.

4. Conclusions.

- Gypsum mortars from Egypt and Poland show a very high degree of similarity which manifests itself in their structures and fillers.

- Differences result from the application of local raw materials and technological capacities.

- Large diversity in quantitative relations /e.g. type of fuel and raw materials/ between individual components in a certain way, allows to modify the properties of gypsum mortars /e.g. durability and abrasibility/

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81/10/11

A STATUE IN BORGOMANERO (ITALY): RESEARCHES ON DECAY AND CONSOLIDATION TREATMENT

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Working Group: Stone

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Abstract. The characteristics and the causes of decay of a stone taken from a statue in Borgomanero (Italy) have been examined before undertaking a study of the conservation. Chemical, mineralogical, petrographical, physical analyses have been performed. The alteration products have also been analyzed and correlated with the environmental temperature and relative humidity.

On the basis of the obtained results, the most suitable conservation treatment has been chosen. The work metodo logy (cleaning, consolidation, protection) is extensively described together the employed products.

INTRODUCTION

This work is a survey of the causes of decay and of the conservation procedure carried out on a statue repre- senting a "Madonna", situated in Borgomanero (Novara-Ita ly). The statue, made by an anonymous XVII century sculptor and given to the town by the Marquise Beatrice d'Este, stands in the middle of a crossroads (1)(figs.1, 2).

A preliminary visual examination of the statue provided the following evidences:

a) the stone, of a rather heterogeneous nature, is compact and fine-grained in some areas, while in others,it is very coarse with large-sized mineralo- gical components (fig.2);

b) an evident alteration is visible on the surface of the stone especially in the upper parts of the statue. The stone surface has become, in fact, rugged, with crusts and loose incoherent material (fig.3), while in less exposed parts and undercuts, black incoherent crusts are present; their thickness varying up to 2-3mm;

Fig. 1 - Statue of "Madonna" in Borgomanero (Italy)

Fig. 2 - Detail of fig.1

c) not long ago, a superficial preservation treatment was carried out on the statue. Unfortunately, it has not met expectations; the resin, in fact, was applied directly on the uncleaned material and - most probably - in a too concentrated solution. The resin,therefore, has not penetrated deep enough into the material, causing thus the formation of thick water-vapour impermeable crusts. These have increased the subsequent attack by the chemical and physical atmospheric agents.

Fig. 3 - Detail of fig.1: the crusts and incoherent material are visible.

Considering what has been hitherto outlined, and realising the seriousness of the situation; the SOPRINTENDENZA AI BENI ARTISTICI E STORICI DEL PIEMONTE, together with the BORGOMANERO LIONS CLUB (Distretto 108-1A), has patronized the study and restoration of the sculpture.

PART I: STUDY ON THE CAUSES OF DECAY

Sampling

As it has not been possible, owing to the peculiarity of the artifact, to carry out a systematic sampling, only small and mostly loose fragments representing the various situations were available as test samples. A particular care was taken in the sampling of superficial crusts wich were very important in determining the causes of decay as well as in inquiring about the previous restoration treatment.

Research methods

Researches developed as follows:

- mineralogical and petrographical observations were carried out on thin sections to identify the mineralogical nature of the stone;
- integral open porosity (cm^3/g) and distribution of the pore volumes as a function of their radius were determined with C. Erba 1000 mercury porosimeter;
- imbibition capacity (I.C. - weight %) was measured by immersing the test specimens, previously dried at 60°C, in distilled water untill constant weight;
- the chemical composition of both stone and crusts was analyzed, particularly as regards sulphates dosage. Sulphate presence would be, in fact, a clue to a possible chemical attack by air pollutant. Apart from metals, which were determined by means of atomic absorption, all other determinations were done with traditional analytical methods;
- the resin previously employed on the statue was characterized with I.R. spectrometric measurements on acetone-extracted films, employing a Perkin-Elmer instrument. Identification was achieved by comparison with I.R. spectra of commonly available resins.

Experimental results and discussion

1. Stone

1.1. Mineralogical - petrographical analyses.

These proved the essential sedimentary detrital nature of stone, coarsely grained with a bad classation, cemented with little calcite and dolomite, with granulometry varying from microcrystalline to spathic. Other minerals, in decreasing order, are:

quartz - in single crystals or polycrystalline crystals. In the former, fracture due to alteration phenomena are often visible. It is also present as calcedony-quartz;
K-feldspar/plagioclase - in sometimes fractured crystals, slightly altered by kaolinization;
muscovite - either in dispersed or quartz-associated lamellae;
opaque minerals - such as limonite and, subordinately, hematite;

a few small epidotes are also present. Fragments of calcareous rock containing micritic-textured pseudo-ooliths appear in great number.

Some of the most significant sections are shown in figs. 4 - 5.

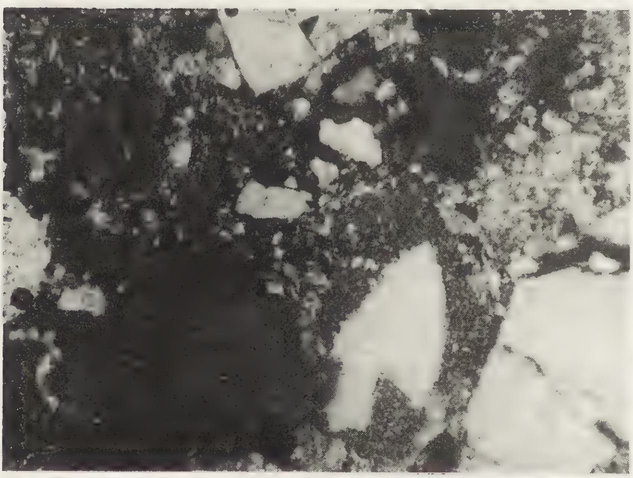

Fig. 4 - Micrograph shows a crumbled quartz crystal (on the left), an opaque mineral (on the right) and microcrystalline calcite as cement (crossed nicols, 40x).

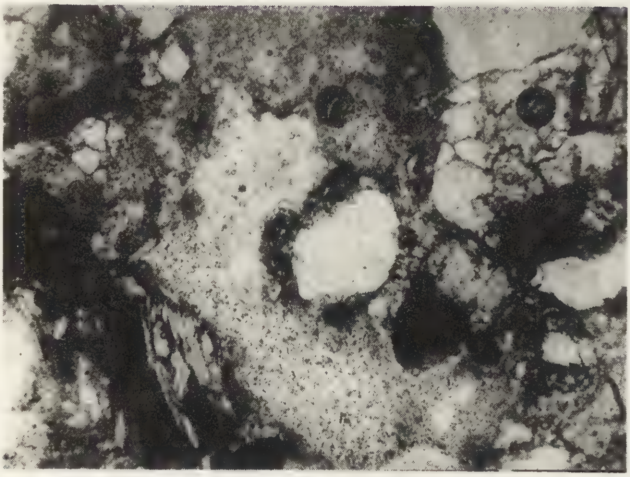

Fig. 5 - Micrograph shows quartz,limonite,muscovite, microcrystalline spathic calcite crystals (crossed nicols, 40x).

1.2. Physical tests.

1.2.1. Porosity

Integral open porosity was determined as 12.10^{-2} cm^3/g (fig.6). Fig. 6 shows also distribution of pores volume as a function of their radius. As it can be noticed, pores of all sizes are present with a clear predominance of larger pores. The remarkable number of pores having a radius of more than 1,5 µm bears witness - as bibliographical data point out (2,3,4) - to the potentially no-freezable material. The results here reported should be obviously considered merely as indicative rather than as absolute values, owing to reduced sizes and heterogeneous nature of the specimens.

1.2.2. Imbibition capacity

A value of 8,3% was obtained for imbibition capacity. Absorption in the course of time has been recorded (tab. 1).

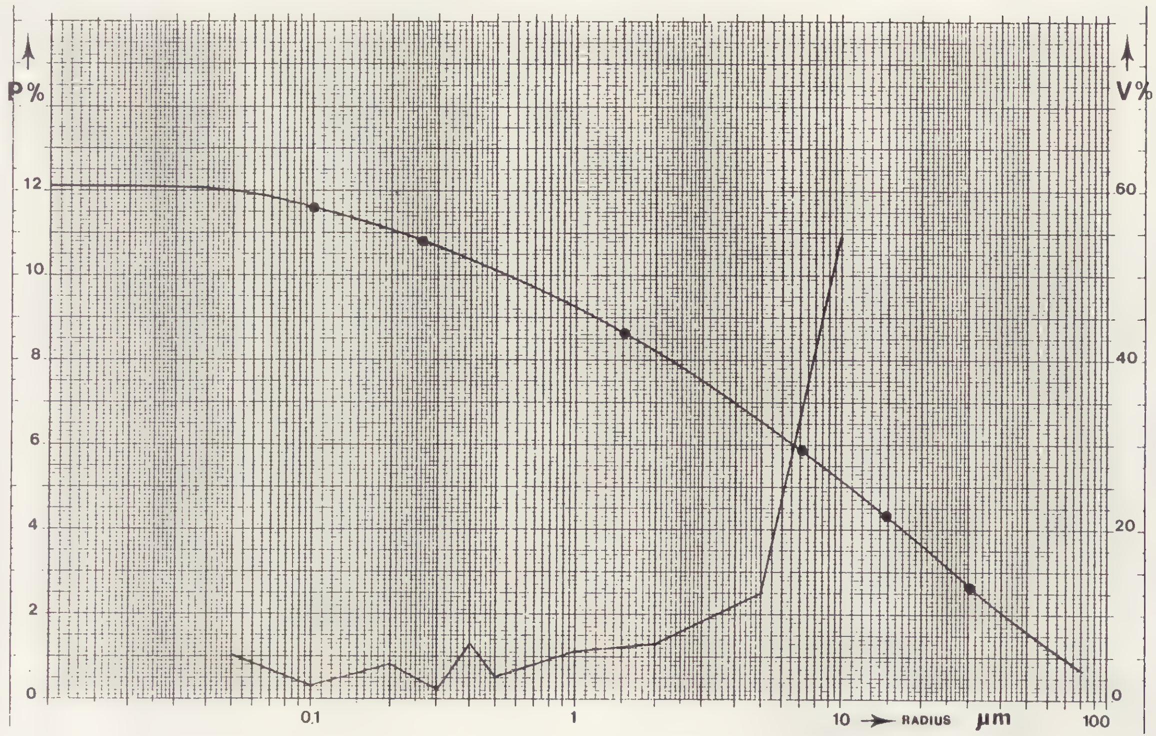

Fig.6 - Integral open porosity and distribution of the pore volumes as a function of their radius.

TABLE 1

time	I.C.%	relative %
1 min.	5,5	66
2 "	6,1	73
5 "	6,7	81
10 "	7,0	84
20 "	7,1	85
90 "	8,3	100

As it can be noticed, the absorbtion rate is rather high; the 84% of total absorption occurs, in fact, in the first 10 min. This value points to a considerable water-absorption by the material in rainly periods, even though there are obvious limitations connected with the scanty supply of material for tests and with the testing methods themselves. Conversely, it can be as well conjected for the same material a considerable availability to absorbe suitably diluted resins.

1.3. Chemical analyses.

Owing to the extreme structural heterogenity of the stone material, chemical analyses could only supply average % values of the searched elements. The results are reported in tab.2.

TABLE 2 (weight %)

SiO_2	CaO	MgO	CO_2	$SO_4^{=}$
33-35	29-32	1-2	22-23+	0,90-1,8

\+ with peaks up to 32%

From a survey of these analyses - and considering also

the results of similar tests performed on stones from the Bergamo area- it can be inferred that the stone of statue under examination is very similar to so-called CEPPO. There is, in fact, a close resemblance between the results of chemical, physical and mineralogical tests on CEPPO specimens, and results obtained on specimens from the Borgomanero"Madonna" (5).

2. Crusts

2.1. Chemical analyses.

Results are reported in tab. 3.

TABLE 3

Sample n.	$SO_4^{=}$ (weight %)
1	3,2
2	5,1
3	3,6

Samples 1,2 come from the upper part of the robe of "Madonna";
Sample 3 comes from the lower part of the statue, under the robe.

Considering the low limestone content of the material, the values obtained are rather high, especially if compared with the stone average $SO_4^{=}$ content which is 1,35%. This fact points to a chemical attack due to air pollutants (such as anydrides and sulphur acid-compounds present in the atmosphere) also as a consequence of the peculiar site of the statue (fig.1). The chemical attack is also favoured by the local average relative humidity which is particularly high (90-95%) since the town of Borgomanero stands at a short distance from two lakes: Lago d'Orta and Lago Maggiore (Hygrometric data have been recorded by the Bemberg Research Laboratory over a period of 25 years).

It has been gathered, therefore, that the decay of the monument is mainly of a chemical nature as a consequence

of air pollution. However, physical alteration with loss of coherence may also occur owing to the stone availability towards water absorption.

The damage due to natural agents is anyway limited, their effects being also much slower than those of air pollution.

3. Characterization of the resin present in the crusts

3.1. Chemical analyses.

A comparison with I.R. spectra of commonly available resin proved that, most probably, the resin previously employed on the statue was an acrylic resin, applicable either in solution or in dispersion (fig.7). The product still shows reversibility evidences.

PART II: CONSERVATION TREATMENT

Information gained through the laboratory tests, gave a basis for the development of a conservation treatment.

Two were the aims it was meant to fulfill:

- restore the original compactness of the material,
- prevent all attacks by external agents.

The treatment was carried out through a set of operations.

Products and methods were chosen on the basis of bibliographic data(7)(8)(9) and of previous tests on one hand, and of laboratory and in situ tests on the other.

Tests performed in situ helped mainly to find out the proper kind of solvent for the cleaning.

Cleaning

Two were the results that cleaning had to achieved in this particular case: eliminate all traces of previously employed resin, and remove the dirt from the surface. Dry methods - that is to say with the exclusion of water - were chosen as appropriate for the purpose on the basis of the data provided by the laboratory researches and also of the seriousness of the stone decay.

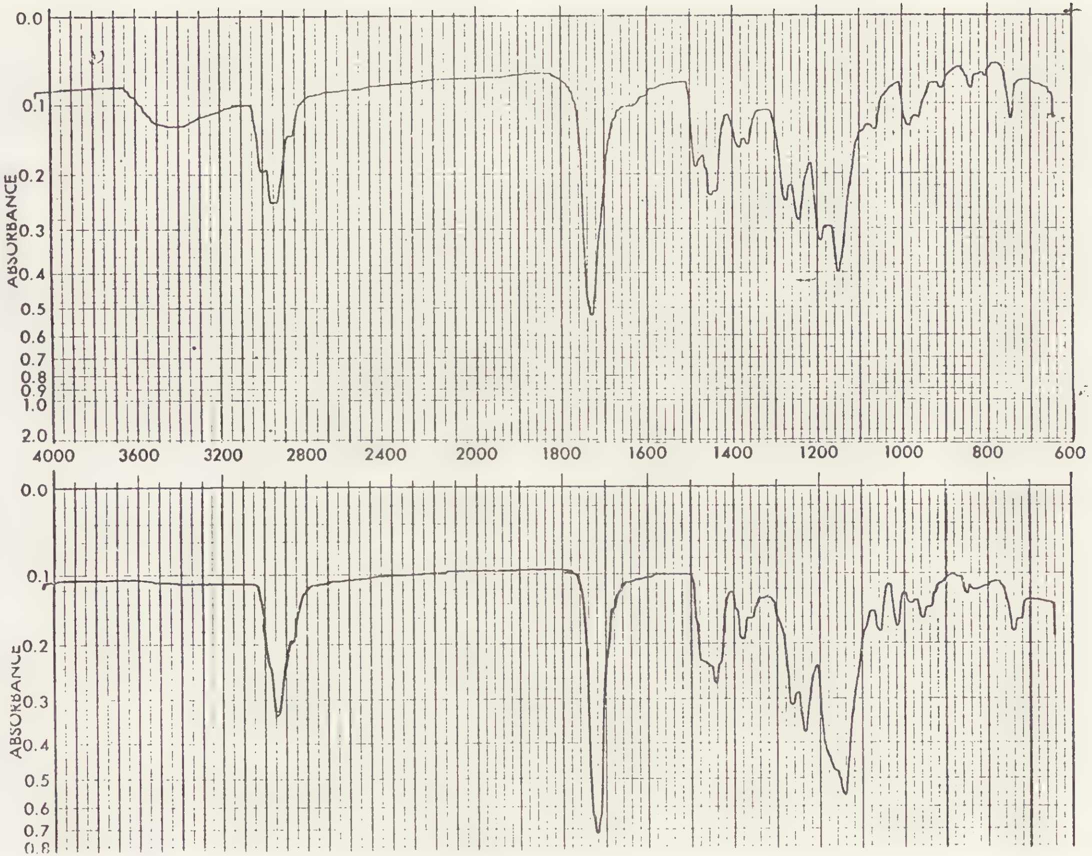

Fig. 7 - I.R. spectra : a) sample extracted from crusts on the "Madonna"
b) commercial acrylic resin.

Resin traces were removed, as much as possible, by applying cotton bands imbibed with a mixture of methyl chloride and tricloroethane.

The whole system was then wrapped in polythene to prevent solvent evaporation.

Each application lasted about 1 hour, and was repeated 4-8 times in according to the amount of resin to be removed. When this application alone did not give satisfactory results - mostly in undercuts - it was necessary to use a bistoury. The work of the performer, anyway, was much lasier owing to the softening effect of the solvent on the resin.

As it has been hinted before, dry methods were used in removing the superficial dust and the black crusts. In particular, the whole surface was cleaned with the "aero abrasive" system employing a glass microballs with a diameter of 30-40 μm at 1,5-1,7 atm and at a distance of 10-15 cm (fig.8).

Filling and strenghthening

No particular filling work was required; only a few cracks were filled with epoxidic resin Ciba Geigy Hy 2925 charged with silica dust as inert component and pigmented with iron oxides (about 0,1%) (fig.9). Silica dust was chosen instead of dust from the statue material to avoid colour change in the stone, especially when wet, as inferred from laboratory tests.

Some completely corroded garrers were taken off being useless, while new ones were inserted of a stainless steel Aisi 316 type, with a diameter of 2-3 mm, embedded in Ciba Geigy 155 epoxidic resin with a Hy 2925 hardner.

Consolidation treatment

For the purpose, ARD 55050 resin was chosen, at a concentration increasing from 5% to 12%, the solvent being a mixture of aliphatic and aromatic hydrocarbons and chlorinated compounds.

The aims was to make the maximum quantity of resin penetrate as deep as possible into the material. To this purpose, a special device was arranged: a "container" was built <u>in situ</u>, fitted to the statue and afterwards, gradually, filled with resin.

Fig.8-a - Before cleaning: on the left, a cleaning test is visible

b) After cleaning

Fig. 9 - Some cracks filled with epoxidic resin are visible.

The stages through which the work developed can be thus briefly described:

a) the whole surface was covered with a spongy acrylic fibre, about 2 cm thick, soft and adaptable to the sculpture morphology. The obviously inert material had twofold purpose; it isolated the statue from the latex coat (see parag. c - below) and worked also as vehicle for the resin (figs.10 a,b);

b) the statue was "dressed" with a medium-textured cotton material having an hairy outward surface (fig.11);

Fig. 10 a-b - The statue is covered with spongy acrylic fibre.

Fig. 11 - The stage after fig. 10: the statue is dressed with cotton material.

c) on the whole system, a natural rubber latex coat was successively brushed thick enough to grant compactness and tightness.

   The performance is much easier if the dressing and latex coating are carried out in bands from bottom to top;

d) to favour the flow of resin, a set of pipes was inserted during the above mentioned phases. Besides, a transparent polythene pipe was set at the base of the statue to check the resin level inside the "container" (fig. 12);

Fig. 12 - The rubber latex coat and the set of pipes are evident.

Fig. 13 - Finally, the statue is covered with a piahly wire net.

e) a very piable wire-net was added to guarantee the system compactness (fig.13);

f) the "container" was gradually filled with resin and impregnation was carried out by capillarity absorption.

A necessary period of time-depending on the lowering of the resin level inside the transparent polythene pipe, generally two hours - was left to elapse between two successive solution supplies to allow a preliminary absorption by the stone. Once the whole "container" was filled up - which took 24 hours - and additional period of 12 hours was necessary to improve imbibition.

The drainage of the resin and removal of the latex coat followed. The consolidated statue was then visually inspected and it was decided to perform an additional impregnation.In places,such as undercuts,folds, ecc. - where the stone was supposed to absorbe more product - the resin was applied by brush until it was no longer absorbed.

Protection

The aim of this treatment is to protect the stone against water penetration and any environmental cause of decay by coating it with a resin film.

To this purpose ARD 56415 acrylic resin (at 10% in aliphatic-aromatic solvent) - with addition of micronized silica as opacifier - was applied twice by spray to the statue.

This work was carried out in September,1980. According local meteorological data,in fact, September appeared to be the best period,being the driest month of the year in Borgomanero. The amounts of working hours and of the most specific products employed are reported in tab.4.

TABLE 4

Work	n.2 restorers	400 hours
Products	ARD 55050 consolidating resin	Kg 80
	ARD 56415 protective resin	Kg 6
	Ciba epoxidic resin for filling	Kg 5
	Stainless steel for gaggers	Kg 1
	Solvent for cleaning	lt 20
	Glass micro-balls	Kg 20
	Solvent for consolidation and protection latex	lt 50

CONCLUSIONS

In the present case, the many aspects of the problem of restoration have been considered. Before restoration, all those laboratory tests have been applied, which are now considered necessary for a correct conservative treatment. The results of such tests have been used as a guide in the treatment of stonework in situ, whenever their transfer to a laboratory was impossible.

At the end of the restoration treatment, the statue appears completely consolidated, although it has a "wet aspect, which is rather usual after such treatments.

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THEORY AND HISTORY OF RESTORATION

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Programme 1978-1981

1. The use of history and theory of restoration in practical conservation (Althöfer).
2. History and importance of documentation in the restoration of paintings (Euler-Künsemüller).
3. The importance of colour theory for retouching (Gräfin zu Münster).
4. Adhesives in art and restoration - definition and history (Rehbein).
5. Patina and associated conceptions of value (Schinzel).

81/11/1

HISTORICAL AND ETHICAL PRINCIPLES OF RESTORATION

Heinz Althöfer

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Theory and History of Restoration

HISTORICAL AND ETHICAL PRINCIPLES OF RESTORATION

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The life-blood of Restoration comes not from the mastering of single problems, but from the highlighting of certain principles, of prospects, of fundamental possibilities of approach, just as it did in the care and preservation of monuments in the nineteenth century and as artistic principles guided restoration up to the end of the eighteenth.

Sheer pragmatism is a danger to any long-term planning. What is needed is prospects, plans and guidelines to direct the day-to-day work and which do in fact constitute what we call tending our cultural heritage. Pure pragmatism leads to deadening aridity in the intellectual process of interpreting art through restoration.

Faith in progress has been undermined in almost every sphere of life. The limits of technical, scientific, social and economic capacity are coming into view. Therefore we must recall the primordial phenomena, the understanding of which is far more urgent than momentary technical solutions.

We must ask what non-technological motivation underlies restoration, for example in preserving indiscriminately by means of integration into coming cultural - or cult - systems. This consideration should be pursued from all angles: firstly to establish it historically, and then to pick out mechanisms and motivations which in certain circumstances may be employed as a 'means' of conservation - or aquire a conservational function by having been pointed out.This is historical fact, not only recordable, but possibly integratable there to be consciously exploited. Ideological, social motives can be detected and employed for the preservation of cultural hertitage. There is no denying that such

arguments were once more effective than any technological methods in modern restoration practice. The convers is also true: destruction, decay through demolition or destruction by way of negation or deliberate omission in restorational supervision, selective practice (Renaissance preservation of the Antique but not of medieval objects) or reinterpretation ('correction' of Mannerism in the nineteenth century) - these have annihilated more thoroughly and comprehensivly, more totally than technological blunders, however devastating these may have been and continue to be.

Ideological conservation may be no more than leaving due space to an era, a style or an object. It is not to screen off, remodel or incorporate - although adaption may be an ideal means of preservation.

Then, technology, especially in an age of faith in technological progress, may be seen in turn as part, or rather, one possibility, an aspect,of ideological conservation. But this only places it in the whole line of diverse possibilities.

Although history teaches that we learn nothing from history (Theodor Litt), we still employ it in all areas in order to comprehend, to put a case, support, destroy, ignore. As it is used as an interpretational aid, an ideological support, as a continuum in the tactical sense, so it is abused with regard to the prevailing interests. We should examine what history does mean to the care and preservation of monuments, how dangerous it is, and whether in the right form it might not become an aid in the preservation of art instead. This it already is, what is meant here is the consciously heightened use of history as a means of pure persuasion.

The condition for this is that we must establish the relationship between history and preservation _phenomenologically_, as it came about _historically_. This phenomenology of the history of the preservation or destruction of art is an important context for con=

servation and care of monuments as practised at a given time. It explains, and with precise analysis it leads us back to an objective view, accordingly distancing the initial, deliberately subjective approach. In retrospect as it were, the subjective point of de=parture becomes a tenable contextualised principle of scientific consideration and does not remain some mere ideology.

This is historical examination no longer as descriptive method but as an aid in the practical application of restoration work to a given article: Toward an understanding of rhythms in monument pre=servation, an insight into the true motives and mechanisms of con=servation work, which must not remain bluntly empirical and tech=nological only. Historical, 'civilisation' perspectives must enter into it and beyond as a signpost to the past, into the study of art and its history. There the same applies, in its selectivity, its chronological emphases, its step-by-step penetration (Hans Sedl=mayr), its blunders and its ideology.
The course of restoratory practice has been governed not by the technical possibilities and considerations, either in detail or in its long history; the determinants of monument preservation were religion, politics, ideologies and science or the ideologie of science. Those in power in the widest sense and mechanisms have defined the manner, extent and significance of restoration and steered what we look upon today as the history of restoration and as 'development'.

Historical study means acknowledging and interpreting a course of events. Thus research covers all spheres, for naturally, the situ=ation is identical everywhere: in economic history, political history, religious history. Whenever there is talk of intergrating in our studies, of relinquishing an exclusively detail-focussed technological treatment of a problem, then this is the sole path with any prospect.

The proper application of history as a means of preservation and the timely use of reflection and reticence could be decisive con=

ditions for conservational protection. History provides evidence for this, too. Dis-covery is at once hope and danger. For the first time a conservational step is taken; at the same time, the protec= tive layer of obscuration and patina is lost. Heritage-conscious safeguards are assured; now the threat of destruction may come from adaption, and ultimately there looms the danger of harm through scientific curiosity and subsequent ignorance. Once analysed, the specimen recedes again into its old anonymity.

It is a sign of ethical self-control and thoughtful preservation to leave the object in its undisturbed shelter and organic shield of maturity and to hold inquisitiveness that includes vanity in check. This applies to individual works of movable art (paintings, for instance) just as it does to entire art environments such as a sepulchral monument.

This is an insight that may only have been made possible by the great successes in laboratory examination and preservation of works of art, and the fascinating discoveries and revelations of recent decades. Success breeds a calmer pproach and willingness to abs= tain: furthermore an insight into the destructive effects of scien= tific alternatives at the outset. It is another step towards putting the credo of progress into proper context.

Not just the aesthetics, but also the ethics of conservation are only considered peripherelly- a convenient pretext for the real restoration by technology and science. Mastering the tools always presupposes mastery of the possibilities: to aim not at the limits of what is possible, but at selection and masterful discretion. It is a challenge to the restorer's sense of responsibility to decide how much of what it is possible to do through science and techno= logy should in fact be used and done. In a philosophy of abstinence there is scope for placing what is feasible at a subsidiary level and ones own attitude under higher aspects. This principle of res= ponsibility (Hans Jonas) emerges as a counterposition to the hither= to prevalent philosophy of action.

81/11/2

PAINTER, MANUFACTURER OF ARTISTS' MATERIALS, AND CONSERVATOR: HISTORICAL AND AESTHETIC SIGNIFICANCE OF THEIR ROLE IN THE SURVIVAL OF A PAINTING

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ABSTRACT.

The role of artist, manufacturer of artists' materials, and conservator, in the life of a painting is examined. Philosophical, artistic, and cultural attitudes may be explained in terms of the diversities and complementary nature of their aim.

Adapting a standard material to the requirements of its use as a tool of artistic expression, by combining the traditional crafts of artist and conservator, with the most recent advances in surface coating technology, is the first step towards ensuring the permanency of the work of art. From this standpoint, the advances in vehicle formulation and their relationship to past empirical studio procedures, are underlined.

The resistance to the anonymity of most of today's painting materials determines a critical review of literature references, which, when conveniently compared with the results of scientific examination of paintings, provides new insight both into the history of materials and techniques, and into the problems facing the modern manufacturer, artist, and conservator.

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This paper examines the influence and possible role three elements play in the life of a painting: artist, manufacturer of artists' materials, and conservator. They are the first vital energies of this museum of hope, in a humanity now marked by the collapse of all its certainties: an approbation of the creative process, the idea embodied in its right form, the joy of work well done. The role of artist, manufacturer of artists' materials, and conservator, in the painting process, follows three basic goals.

The first involves the artist, i.e., the self-teaching side of painting, its use as instrument to study and check the stages that lead to formal synthesis. By succesive gestures the brush deposits on the support strokes of paint which organize the support as a pictorial surface. It is often desired to display innovative techniques; however, to do so entails the risk that in time transformations and/or alterations may occur. In order to be aware of any changes that may take place in a painting over a period of months or years, and to prevent further deterioration of the paint layer, it is suggested that the artist should have a basic knowledge of paint making, and perform a few simple tests for permanency (1). But to what extent can a modern painter become involved in making his own material? The answer would have to be that at least he should acquire that practical knowledge that allows a selection amongst the ready-made materials available (2). Likewise, the exchange between artist and manufacturer should constitute the next step towards improvement, both in technique and material.

In fact, the second goal involves the manufacturer of artists' materials in his capacity to act as a means of communication within a codified material, enabling the transmission of all the characteristics of the art object to the viewer. Living as we do in a mass-production society, our products, e.g. materials for the arts, are rationally designed for certain functions. Nevertheless, there is still space for adapting the standard material to the actual day-to-day requirements of its use as a tool of artistic expression, even in this extreme industrialization of the product (3). This is where we have to rediscover traces of ancient tradition of craftmanship, not by exhuming legendary formulae, but by the understanding of the intrinsic properties and working qualities of materials, both old and new (4).

Furthermore, some of the factors which build up the painting have been explored very thoroughly during the past several decades, and the results lead to definite improvements. It is sufficient to mention the new Chrome Yellows (5).

The third goal involves the conservator. The abstract concepts contained within the work of art itself are endowed with their own independence; however, their understanding by future generations depends on the preservation of the painting, i.e., of a multilayer construction of heterogeneous materials. The problem resides in the way conservators stand aloof from the real process of making the work of art, and assume merely an after the fact role.

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Before describing the practical aspects of this collaboration, it is necessary to understand the nature of the sources available for research. Outdated sentimental theorizing - often developed outside the practical field of painting and of the industry - has been replaced by criticism that attempts to return to a careful examination of early literature references as well as of works of art, by means of etymological and scientific examination.

The abundant crop of technical studies that have appeared in recent years, can only be explained by means of this critical approach, itself the consequence of a general disappointment in the achievements of earlier times (6). Another cause of this trend might be the more-or-less conscious resistance to the standardization and anonymity of most ready-made materials available, and consequently, of art itself.

In any event, traditional manuscript material can be read for information and fully exploited by artist, manufacturer of artists' materials, and conservator. In addition to its use for the study of the history of painting materials and techniques, this procedure offers a convenient means to make a comparison with the results of scientific examination performed in conservation laboratories (7). All of this work demands a combination of the traditional crafts of the artist and conservator, with the knowledge of the most recent advances in surface coating technology (8).

For the sake of brevity, here is only one example. The Byzantine treatise known as The Athos Book, probably based on original textbooks of the tenth or eleventh century, alludes to ancient varnishes thus prepared:

> "Put some oil in a copper vessel and expose it to hot sun for forty days... When it has the consistency of honey it will be good...."

> "Take four parts of oil baked in the sun and three parts of pegola [colophony]. Put them in a vessel on the fire to melt together... If it is too thick, add naphta or raw oil... If you have good mastic, take instead two parts of pegola and one of mastic...."

In the fifteenth century, Le Begue describes the preparation of a purified oil:

> "Preparation of oil for distempering all kinds of colors. Take quicklime, and equal quantities of white lead and oil, expose these to the sun without moving it, for a month or more. The longer it stays, the better it will be. Then strain and keep the oil."

The opinion of Rubens has been recorded by his physician, Turquet De Mayerne:

> "The best varnish resistant to water is made of siccative oil, much thickened in the sun over litharge (try over lead white) without any boiling."

Eraclius, in the copy of his treatise in the Le Begue Manuscript, describes a drying oil fit for painting:

> "Put a moderate amount of lime into the oil and boil it, skimming occasionally; then add white lead, according to the quantity of oil, and place it in the sun for a month or more, stirring often. The longer it is exposed to sun, the better it will be. Afterwards, strain and keep it, and mix colors with it."

The Italian process, recorded by Cennini, is less complex:

> "...use a moderate fire, as the more slowly the oil boils the better it will be. Let it boil till it be reduced to the consistency of a medium; it will then be good. But for mordants, when it turned to the quality of a medium, add an ounce of liquid varnish... for every pound of oil...."

> "Oil may also be prepared in another mode: it is thus fit for coloring... Put linseed oil in a bronze or copper vessel and in summer keep it in the sun... leave it exposed till it turns to the quality of a medium and it will be perfect for coloring...."

It is noteworthy mentioning that sunbleached and sunthickened linseed oil (9) form a quick drying, thoroughly hardened, smooth film of great durability. Research done in the United States by Permanent Pigments shows that the heavier bodied sunthickened oils, longer exposed to the sun, accelerate the drying of raw oil vehicle paints in proportions as low as 5%, without markedly affecting the consistency of the paint.

Cennini remarks that oil painting is much used by the Germans, i.e., by artists north of the Alps; this can be understood to refer to the practice employing the vehicle described by the Strasburg Manuscript (10).

De Mayerne also describes the preparation of an oil similar to today's litho varnishes:

> "Ink for printing. Take walnut oil as much as you like, boil it in an open earthen vessel until it becomes of the consistency of honey or of varnish...."

The following conclusions can be drawn from the passages cited above. On the one hand, the Byzantine Manuscript, Cennini, Le Begue, and Rubens, mention a raw oil purified by sunbleaching, or a light-bodied sunthickened oil, which may acquire a heavy body or a varnish quality if exposure to sun and air is continued. On the other hand, Eraclius, the same Cennini, and the Strasburg Manuscript, describe a heat-purified or refined oil, which also may acquire a thick consistency, if such a product is desired.

When fluid, these vehicles are similar to today's refined oils, whereas the thicker products are respectively similar to fat or sunthickened oils, or to light and heavy bodied polymerized (Stand) oils (11). Other substances may be used during treatment in order to obtain certain desirabl properties. Currently, heat may be used to some extent in refining.

Both processes can be prolonged until the oil acquires a thick body, like honey or like a varnish; this means that up to the seventeenth century a varnish, be it oil or an

oil-resin compound, was thick and flowing, of the consistency of today's polymerized linseed oil (Stand Oil). The fluid oil is used for grinding colors. The thicker product may be added to the paste in small amounts. In regard to varnishes, the thick product known as vernice liquida, which, as shown above, is of Byzantine origin, consists of either a thickened oil amber colored, or of resin cooked with oil, i.e., an oil-modified resin. The legendary Venice amber varnish is nothing else but one of the above varnishes.

The passages cited above show that, although old accounts are not always reliable due mainly to innacurate compilation and translation, accounts written by professionals describe the practice of oil painting in all respects relating to the most scrupulous preparation of materials. This is possibly the most important point. The patience required to handle materials is so extensive that anyone who had attempted to prepare one's own colors - most conservators and a few artists still do it - gained a new respect for the craftmanship of old painters, and, at the same time, gained new insight into the problems facing the manufacturer. In fact, many of the empirical processes used in past times have been developed into industrially and economically feasible procedures, leading to advanced formulations of vehicles.

Indeed, the advent of acrylic paints, and especially of paints and media based on oil-modified alkyd resin, could under certain conditions prove to be the solution to the question of permanency sought for over centuries past, since they are virtually foolproof in terms of handling, although by no means yet equal in quality to the best oil paints (12).

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Let it be emphasized here that the suggestions set forth in the foregoing regarding measures for ensuring the permanency of concepts embodied in a material, are more in the nature of minimum basic practical expedients rather than the ideal for permanency.

Even though all three professions originated in one single generative source, they remained separate from each other because of particular industrial, economic, technical, and social considerations rather than because of difference

in philosophical, artistic, or cultural attitudes. Many of the characteristics that form their very foundations can in fact be explained in terms of the diversities and complementary nature of their aim.

Then, once the phenomenon is seen as belonging within the specific field of painting, might we not hypothesize the existence of straightforward influence of it on painting, with no confusion of boundaries between the respective fields?

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(9) Refering to boiled oil, Cennini says fallo bollire per mezzo, and quando e tornato per mezzo. About oil exposed to sun he says tieni tanto che torni per mezzo. This is usually translated till it be reduced one half or till it turns to half. Firstly, although some of the oil is consumed through boiling, it does not turn to half. During exposure to sun, the mucilaginous material may seem to be half of the oil if a shallow container is used. The final product in both cases is purified and bleached, and slightly more consistent than the original oil. Therefore, we refered to it as having the quality of a (painting) medium. Secondly,

neither oil is thick, for a thickened oil is unfit for grinding. In fact, in order to obtain the mordant, an addition of varnish is necessary.

See also Mueller, p. 121.

(10) The Strasburg Manuscript describes an oil painting technique attributed by us in a previous paper to the times of Van Eyck. The oil is prepared by heating with pumice powder and bone ash. It is then mixed with zinc sulphate and exposed to the sun. The oil is used for grinding. A small amount of a thick oleo-resinous varnish is mixed in to the paste. To test whether the varnish is well cooked, a drop of it is taken on a knife. Upon touching with the finger, it should draw up like a thread.

See also Doerner, p. 52.

(11) Fat oil is the name given in England to sunthickened linseed oil. "This fat oyl" says Smith in his Art of Painting 1687, "shall not only make your colours dry sooner than plain oyl, but it shall also add a beauty and lustre to the colour; so that they shall dry with a gloss, as if they had been varnished over."

Instead, Lebrun 1635 remarks: "Fat oil is made by putting a bag of litharge into a pipkin with oil, and boiling it... when cold the oil becomes as clear as rock-water."

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81/11/3

ADHESIVES AND THEIR RELATION TO THE HISTORICAL DEVELOPMENT OF RESTAURATION

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ICOM Committee for Conservation
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ADHESIVES AND THEIR RELATION TO THE HISTORICAL DEVELOPMENT OF RESTAURATION

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In regarding the history of restauration , it appears necessary and meaningful to look at the historical evolution in the context of the materials and methods used in restaurating .
Evidently , one examines those materials and techniques which in the course of the development of restauration have proven - and still do today - especially important and variable .
Some of the essential materials used are the various adhesives , starting with the application of glue or wax all the way to modern adhesives . With respect to restauration and painting techniques adhesives are of special significance because they have always been used in foundations as well as in the laying down of loose layers of paint .
For these reasons the restauration center of Düsseldorf has been conducting experimental research on the field of adhesives together with Henkel KG .
In view of the multitude of various adhesives - there are about 1.000 different "glues" of which roughly 80% find industrial application - we emphasize 2 groups which appear especially interesting to the restaurator : on one hand the so-called do it yourself products ,

such as Pritt , Pattex , Stabilit-Palette etc., and on the other hand such craftsmen's products as Ponal and Metylan paste .

One can classify agglutinants according to different aspects , such as their consistency : powder , paste , liquid , solid ; or their modes of application : wall-paper paste , paint glue , wood glue , metal adhesive ; or according to their properties : adhesive , enamel glue , two component adhesive etc .

In this paper we would like to present a classification according to their origin : glues made of

A natural products
B chemically modified natural products
C synthetic products

ad A. <u>Natural Products</u>

Today we use only a few glues based on natural products that have not been modified :

1. natural rubber : gum arabic
2. asphalt gum
3. Copal resins : colophony , shellac
4. Caoutchouc : from <u>Hevea</u> <u>brasiliensis</u> ; used as the naturally occurring dispersion in water : Hevea latex , or as a solution in organic solvents (e.g.methyl chloride)
5. bone , skin , fish glues : hydrolysis of collagen
6. casein glues : treatment of milk casein with alkali or ammonia yields casein glue

ad B. <u>Glues made of chemically modified natural products</u>

I <u>Plant glues</u>

This group consists of those water soluble glues obtained from high molecular carbohydrates and plant proteins :

1. starch pastes
2. dextrins

3. water soluble cellulose glues

II <u>Cellulose glues , soluble in organic solvents</u>

a) Nitrocellulose glues : treatment of cellulose with nitric acid : cellulose nitrates are soluble in such organic solvents as ethyl acetate

b) Acetyl cellulose

III <u>Waterglass glues</u>

Waterglass (liquid glass) is obtained by heating sand with soda or potash to 1.400°C ; sodium waterglass (silicate of sodium) used in gluing glass , ceramics , wood , paper ; potassium waterglass (silicate of potassium) used as binding agent for paint

ad C. <u>Glues based on synthetic products</u>

These adhesives are subdivided into

I. duroplasts

II. thermoplasts

III. elastomeres (synthetic caoutchouc products)

I. <u>Duroplasts</u> including
- polycondensation products
- polyaddition products , such as polyisocyanates , epoxy resins
- poly unsaturated polyesters

II. <u>Thermoplasts</u> including
- vinyl polymers , especially polyvinylacetate , polyvinylpropionate
- mixed polymers of vinyl acetate and vinyl chloride, vinyl laurate or vinyl maleate
- important raw materials for the production of adhesives : polyacrylate , methacrylate

III. <u>Elastomeres</u>

This group of adhesives represents an intermediate between duroplasts and thermoplasts . The gluing process is mostly carried out by gluing 2 surfaces which

have been covered with adhesive (contact gluing) . There has been extensive development in the field of elastomere glues since World War II.

81/11/4

THE PROBLEMS OF AGING

Hiltrud Schinzel

ICOM Committee for Conservation

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Working Group: Theory and History of Restoration

THE PROBLEMS OF AGING

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Natural aging causes physical and chemical changes in the material of which a work of art is made. This transformation affects chiefly the colour and surface structure, but less the composition of the work; so the effects of aging become a real eyesore where composition is limited to a minimum, as it often is in contemporary (for example, Minimal) art.

A different effect of aging is to distance an object in our awareness as we become more and more removed from it in time. The object becomes just that and less and less a carrier. A current work of art is closest to us emotionally, because it affects us in the negative and in the positive sense at the same time as it is the quickest to stir the intellect[1]. A removed view is more objective since it is less weighted with the sensation of immediate concern; on the other hand just this lack of emotional immediacy limits the experience and therefore the knowledge or "message" that such a view can communicate. It is rather easier (within this necessarily restricted scope) to interpret a work of art in a removed, objective way if it is old.

The objectivity itself is only relative, however, because we are incapable to perceiving anything existing outside the possibilities of our contemporary awareness.

The reason why an older work of art does not irritate us lies in processes of experience, habit, in short, deadening of the senses in relation to the work. Not the work loses revolutionary content, but we lose our sense for it in direct proportion to the work's diminishing topicality as diminish it must by its "having aged". The less topical it is, the less we can understand it, but the more it is endowed with foreign values such as dignity, nobility, beauty, romance. The viewer encapsulates himself in the "enjoyment" of art (Kunstgenuß). i.e. his consumption of it, a cocoon where he can feel as cosy as in a hot bath: no effort is called for on his part. The viewer will become aware of the demands put on him by a modern work at the latest when he finds himself having to admit that he cannot understand it, however, and that his comprehension also prevents him from enjoying it. Thus the modern work of art leads him by its very selfassertion to the fundamental truth that genuine "enjoyment of art" is to be had only through understanding the artistic message, in other words it is primarily intellectual. Of course, this does not mean that the Moderns can only be approached properly via incomprehension; but the values a layman enjoys in older pieces are not inherent in the work at all, he creates them himself by association while looking at the old work of art. The Dadaists provided an example of resistance against this consumption of art, and the most radical among them must have been Duchamp with his ready-mades. It is both paradox and symptomatic that these were at once

aesthetised, so that the effect was the opposite of the intended one.

There are certain optical laws that produce a visual sense of pleasure and harmony[2]- or the opposite. The former satisfy us and we are accustomed to call this an aesthetic satisfaction, while the disharmonies become familiar in time and we integrate them, until we come to feel that old art is something we call "beautiful"[3]. In fact, it is the absence of the shock of being affected personally, of being involved, which modern art exercises; it is the instinctive certainty that no personal demands are put on one, that makes the old masters so pleasant in the eyes of the average onlooker. Therefore the romanticism with which we approach old art is really self-deception, the aggressive reaction to the moderns a head-in-the-sand tactic.

Restorers are usually content to tackle the problems of preserving the material state, whereas the deal is always to take the old work of art from its present to its original condition. It has taken a very long time for them to realise that this retrogression is a utopian project, as it is simply impossible to tell precisely what the work might have looked like before aging. The consequent affirmation of patina was voiced when C. Brandi declared it as historical, documentary material and rejected its removal as historically untenable.But it must be considered whether the patina, apart from being the material evidence of an accumulation through time, might not also be plain and simple muck, and an all too yellow varnish a nuisance and source of historical misinterpretation. To declare patina a positive byproduct of history is certainly an elegant solution, but especially in view of the inter-

ference effect of too rapid aging in modern art, it may be too simple after all.

Were the work of art only for the historian's benefit, then we today would not hesitate to remove as much of the patina as possible and reject additions. Phenomenologically, patina could be compared in historical terms to sheer painting-over - but the damaged portion represents a real material loss. (It must be rememnered that the pigments are subject to tonal, age-determined changes even under the patina). So certain questions no longer apply to the restorer if the criterion is that of history; but they emerge if he sees himself in the service of a public. We must ask ourselves whether it is more tenable to restore a work of art; for the sake of a certain unity and inevitably falsify the original, or to present the public with a fragmentary work of art; that is, we must act either socially or for an elite.

Now these questions bring us back to the essential opening debate as to the purpose of art, or what the viewer misinterprets in it to a greater or lesser degree (in the end, then,the restorer cannot hide behind an art-historian's words in the execution of his profession, which he must recognise as an impasse; he has to seek his own justification for what he is doing)

Owing to the above, the risk of misinterpretation is not as great with the moderns as with old art, but it is probable that in many cases there is no interpretation whatsoever going on. Damage, being structurally different, might even make interpretation easier in that the intrusion points out what it is that has been interfered with.

One should ask whether the viewer's structures of consciousness as described above might not justify a basic distinction in the restoration of contemporary and of older art: to me it seems a fallacy not to reconstitute a modern work, besides, the deteriorated (=age-affected) work would be transferred into a current art trend (process art) in which processes of aging and time are intended to be manifest. Also many works of art incorporate this as a negative potential message owing to their great sensitivity to aging, they also need to appear intanct at least for the short duration of their topicality.

It is harder to decide what to do with older art. Whether, for example, one may assume that the viewer's relative incomprehension of old art entitles us not to undertake repairs (also from the point of view that the viewer will eventually get used to the fragmentary state) or at worst excuses such action, is another matter. Perhaps I may echo Wittgenstein's pithy remark, "What can't be spoken about is better kept quiet" and say what can't be understood can't be interpreted , either.

Notes

1) As elaborated below, I would not include wallowing in aesthetic delight in "genuine feeling"; the former is rather the product of a misconception of the purpose of art, as a means of delectation. Here old is confused with venerable, and every old object is stamped with the seal of "beautiful", "good", "precious". Art is intended to convey knowledge of a spiritual, philosophical kind, however, and as such it is much more significant.

2) See, for instance, R. Arnheim, Kunst und Sehen, 1978

3) Also see M. Heidegger, "Der Ursprung des Kunstwerks" in Holzwege, 1950: "Aber das (Kunst)Werk ist kein Zeug, das außerdem noch mit einem ästhetischen Wert ausgestattet ist.."(But the art work is not just a thing to which aesthetic value has been appended), or W.Hofmann's Gegenstimmen, 1979,p.242, Arnulf Rainer...die Ästhetik des interesselosen Wohlgefallens (the aesthetic of pleasurable indifference).

81/11/5

THEORETICAL ASPECTS OF RESTORATION

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ICOM Committee for Conservation

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THEORETICAL ASPECTS OF RESTORATION

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Summary

Theoretical aspects of restoration till now lack a common methodological and univying background mainly due to a certain neglect for operational restorative activity. An operational aspect of the future restoration theory can be viewed on two different levels. The first of these levels is purely empirical with emphasis on the order and meaning of operations. The second one is submolecur one with emphasis on inner dynamics of a restoration process.

European science relatively often employs the notion of the theory of restoration, usually on the level of pure discourse. There are some voluminous monographs on the said topic, but a current empirical practice flows far away from any theoretical beacon. Neither the organised restoration services nor privately working restorers care much about requirements of abstract theory. Futhermore, basic definitions of theory considerably diverge, there are neither common terminological dictionaries nor unified methodological approaches. No wonder that accordingly absent are commonly shared views upon the most essential items of theory. At the one side there is a wide range of parallelly executed drafts of restoration theory having rather a few mutual points of agreement among them, at the other a loose assemblage of disconnected principles, postulates, conceptions without a uniform methodological background. So a codified or even a unanimously accepted theory of restoration virtually lacks any tangible existence as compared with other humanitarian disciplines.

Extant now items of the theory were shaped mainly within the sphere of architectural restoration. Due to

this particular circumstance they tend to appear useful and workable only there, being far less liable to usage in the sphere of museum restoration. Numerous elements of architectural interiors - wall and easel paintings, sculpture, carvings, draperies, gilding and so on - are usually considered as secondary and of no special importance for theoreticians. Museum collections as a whole have the same poor luck almost without exceptions.

The absence of empirically applicable theory in the sphere of museum collections prevents any further progress in this field and leaves it overburdened with huge and quite unmanageable heap of contradicting theoretical theses and postulates.As a rule these theses and postulates have either aesthetic, ethical, historical or juridical character. They lack not only a common methodology but principles of mutual coordination and decoding as well. With all their scientific and theoretical importance they cannot be forced into a coherently structured system. Besides the mentioned there exist some other aspects aimed mainly at analysis of monuments materials or materials (glues, varnishes and so on) which are applied during the process of restoration and introduced into the original structure of historical and/or artistic object. Much more is neglected a dynamics of that process on the submolecular level, though it is one of the most promising directions of the research for years to come. According to widely held opinions the very employment of analytical techniques together with optical and X-rays methods amounts to something which seems rather an acceptable substitution for restoration theory. It is a regrettable delusion. The theory of the said techniques and methods remains and will do so purely physical and chemical in its essentials not restorational any more. The most

distinguished and experienced restorers can afford no decisive impact on development of those methods. Their possibilities do not reach beyond empirical definitions of a task pertaining to the moment but a real decision of that task would belong to scientific personnel only. Purpose ful development of scientific methods lies out side restorers abilities. But theory of restoration should by definition belong to the restorers field of mental activity not excluding of course art historians or analysts working together with restorers.

Just in the some way does not exhaust the conception of theory special technology a search for and a development of synthetic polymer materials instead of traditional glues and varnishes. Restorers usually employ newest materials as if they were old ones without a due regard for their peculiar qualities and for modified proceedures of their application.

Nobody would deny a steadily growing importance of special technology for the future theory. But nontheless it cannot replace theory in general even if champions of special technology claimed for it overhelming primacy.

All the aspects mentioned above from aesthetic to technological ones do not stem immediately from nandy manipulations of restorers, rather following them as unobligatory accompaniment. Any of these aspects can be kept in account or ignored altogether, vary unpredictably in scale or intensity, appear on the first plan or recede into the background without any considerable effect on the said manipulations. A traditional restorer would employ his means independently of all that in equally traditional manner relying more upon the tastes of owners or society than upon any theoretical requirements prescribed by interests of science. In short there is no organic interconnection

among all extant theoretical aspects and there is no consequent integration of them into a coherent system which would allow to improve restoration standards to the degree required by modern science and technology. Therefore a genuinely scientific methodology of restoration still remains a desideratum despite the flood of publications full of exquisite highbrow phraseology.

In case of proper investigation of all extant definitions of theory it would be easy to pinpoint exact bents of their authors with particular respective predilections for aesthetics, art history or for chemistry and optical physics, electronography, neutron activation and so on. But invariably those definitions either ignore or severely underestimate restoration itself as a multiphased and complicated process, as a dynamic phenomenon, which involves applications of numberless theoretical aspects, each time in different degrees of their mutual coexistence and interaction. The sequence of operations, the very backbone of real restoration activity, almost never figures in lengthy theoretical expositions. In other words an operational aspect of restoration, surely primus inter pares, always trail behind any other less important, be it aesthetic or analytical one, though restoration will for a long remain a traditional skill whether anybody wants it or not.

As an underlaying but powerful reason here serves a sociologically typical for bordering disciplines circumstance of restorers disbelief as to any theoretical problems. Being pragmatically oriented and not easily convinced in the usefulness of dry bookish thinking, they stand aloof to theory which on the contrary appeals to those who do not directly lay their hands upon instruments and objects. Abstract character of theoreticians' personal involvment evidently reveals itself

in unintentional neglect for operational activity.

But without the latter all other aspects will never be able to undergo a necessary interweaving. Only after that it would be possible to find a unifying coefficient or module for a diagrammatic net of mutual interrelations, a sort of coordinates system for the initial comeasurement of those interrelations. As a preliminary condition for the development of the future theory, if proposed herein views are valid, it would be necessary to reach some adequate definitions beginning with that of "restoration process" and then of all involved operations in turn. Evidently it would be advisable to divide the first of these definitions into smaller two subtypes according to the following two levels of analysis and interpretation. One of these two levels is largely empirical, when the restoration process is viewed from out side in such a way as it is usually watched by a naked eye whether of restorer himself or of any art historians. At this level the primary task can be described as a scientific and methodological verification of the meaning and of the sequence of restorative operations. The said sequence should provide automatically as far as it is possible the desired final result of process, optimal one if not ideal. The only misfortune is this that today nobody knows with necessary precision what this final result is as such. The second level is mainly submolecular, when the restoration process is viewed from inside in such a way as it is usually watched through any special system of lens. Here it is obligatory to keep in mind a dymanics of process and not always strictly predictable results of interaction between material structure of an object itself and materials of restoration introduced into it.

So factors liable to consideration at each of

these two levels differ in no small degree and it is far from certainty as to the rules of their mutual agreement. Nontheless just the latter is the distant aim of the future restoration theory.

Only few though important theoretical aspects were mentioned above. There are many others somewhat more marginal perhaps to the direct restoration process, but they influence it which fact demands at least a passing regard for them. Beneath only arbitrarily chosen ones can be cursorily referred to.

For example utterly neglected are sociological problems of restoration as if they were too simple and of no importance for social and cultural interests of time. But due to this neglect most precious monuments and art objects not rarily suffer a damage sometimes during the very process of restoration. The other gravest problem is that of required but not easily achieved coincidence of professional restorers' motivations with those of their managment and of society as a whole. Some cleavages, often latent ones, are present invariably.

There is no system in the study of artistical and aesthetical criteria of the epoque, of their gradual changing and of their varying impact upon the aims and problems of restoration. Extremely difficult for practical handling are such aspects as modern education and training of personnel, as real employment of ethical criteria and their coordination with aesthetical ones, as a social function of restoration in the improvement of cultural standards, at last as managerial, financial and organisational conditions and so on. All these aspects are still subject to the sway of unescapable empiricism. A really scientific methodology of restoration is the only guaranty for satisfactory preservation of our general cultural heritage.

ACCOMPLISHMENTS IN THE REALM OF CONSERVATION OF MOVABLE ART OBJECTS IN SOUTHERN POLAND AFTER 1945

Władysław Ślesiński

ICOM Committee for Conservation
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This article is a continuation in the presentation of the history of conservation and restoration of art objects in Poland /during the 4th Trienale in 1975, the years 1800 - 1918 were presented,and the years 1918 - - 1939 on the 5th in 1978/.

After World War II conservation of movable art objects acquired a new character;it developed and transformed. Principles methods and means were changed.Major changes also took place not only in the quantity of accomplished conservation and restorations, and in the amount of research work,but also in the number of qualified conservators.

In the place of a few conservators whose knowlege and qualifications were a result of self-instruction and experiments.Now Poland has one of the largest working forces of conservators with specialized higher education in this field.The Krakow - area Union of Polish Artists,conservation section registers about 35 % of all Polish artist-conservators. This number of specialists can be envied by many countries posessing a much larger amount of historical art objects than Poland.

A much larger and more important role is played by conservators in the every day functioning of our museums. Furthermore the number of conservation workshops in Kraków was enlarged,and the already existing workshops in the National Museum in Kraków and in the Wawel castle were expanded as well.New workshops dealing with the conservation of ceramics,leather and metal were organized in the Museum of Ethnography; paintings,sculpture and organs in the State Firm Conservation of Monuments Workshops / PP PKZ /,Kraków branch; and graphics and books in the Jagiellonian University Library.

The amount of work once accomplished by one or two museum workshops in which only a few conservators and privately working amateurs were employed,has incomparabily risen.

Today conservation and restoration work is not only done in the museum workshops,but also in the PKZ workshops,in the Polish artists union,conservation section workshops"ARA", in the dept.for conservation at the Academy of Fine Arts in Kraków and in associated workshops or the co-op "Plastyka".

The acquirement of professional skills prior to 1947 was accomplished by means or self-education,experiments and experience.This system of achieving an occupation,based often on the harboring of trade secrets,cleatly did not promote development in this field,and usually was a "nourishment" to a few individual pseudo-researches and improvisators. Of course by no means were they able to cope with the ever demanding requirements of conservation.When the field of conservation of art objects stabilized as a branch of sciene, the problem of educating future conservators became very important.In 1947 the art academies in Kraków and Warszawa organized an official educational program for the conservation of movable objects.This fact can be recognized as a major accomplishment in Polish conservatio in the years following World War II.

Since 1945 in the southern Poland area conservators salvaged a large amount of historical art work - murals,painted ceiling beams,sculpture,for example.It is not possible to sum up all that has been done.Statistics,anyhow,can not illustrate the expanse of such operations,nor the quality and execution of the technical and artistic solutions.We know, however,that contemporary conservation is undeniably connected with a fair amount of research work and requires technical knowledge as well as artistic aptitude.

The fundamental characteristic of contemporary conservation is the expansion and complication of the problems:the subortination of all the therapeutic methods,respect for the authentic,and basing all activities on research work.

The conservation of art exploits the conquests of sciene and the methods employed are often based on research and the adaptation of new areas of knowledge. The need for increasingly precise research and analytical methods

resulted in the diagnostic participation of many scientific and natural scientific fields.The inclusion of many of these areas in the work of the conservator and the result of collaboration with many specialists in the conservation of art work warrants the expansion of this field.Most conservation work is carried out by a team.

The evolution of conservation is not only the consequent introduction of new methods and materials,but also the gradual exclusion of other methods and materials,and also the elevation of workmanship.As a distinquishing attribute one must recognize the linkage of scientific research with practical realisation.

Considerable research work has been done in the Kraków area and is of prime importance in several areas,such as, the technology of conservation,the conservation of murals, the theory and history of conservation,and the history of art techniques.

Conservators from Kraków were the first in Poland to work out a procedure and employ polyvinyl acetate in organic solvents in the conservation of Gothic wall paintings in an Augustine cloister in 1955-56 /J.Æ.Dutkiewicz,Z.Medwecka, Z.and T.Knaus /.The first transfer of the paint layer with the ground layer of a 16th c.painting from Siemiechów into a /poly/methyl metaetylate support was executed in 1958. In the 60 s a nater emulsion of polyvinyl acetate was employed in the lining or paintings from Bochnia,Żywiec,Nowy Sącz and /poly/vinyl acetal in 1967 in lining a painting from Puszczyna.Other inovations include the employment of transparent plastic facing while transfering murals the "strappo" method in Stary Sącz /1964/ ; a new analytical method, microstereodiography,worked out by R.Kozłowski,or another by the same author based on the diagnosis of microorganisms in chalk.Rudolf Kozłowski also constructed a mechanism for angle radiation of X-rays,a negative mirror stereoskop with a diagram for establishing depth a slide for automatic calculation of the focal length for IR fotography,an auxiliary stretcher helpful in the lining of paintings with wavy deformations,

and, several new types of cradles for paintings on wooden supports.

The accomplishments of the Kraków area in the technology and techniques of conservation are quite impressive and have not been sufficiently popularized, and have even been purposely passed over. The results of this output are stated, for example, in the research papers of Danuta Kunisz and Maria Ligęza, Laser Microanalysis in the Examination of Works of Art /"OZ" Ochrona Zabytków, 1970,4/ and Andrzej Oberc, The Application of Microscopic Petrographic Methods to the Conservation of Works of Art /"BMiOZ" Biblioteka Muzealnictwa i Ochrony Zabytków 11,1965 / and A.Oberc, S.Fiertak, The Application of Saturated Gipsum Solutions for the Consolidation of Stucco Work /"OZ" 1974,3/ ;Barbara Kwiecińska, Maria Wirska--Parachoniak, Włodzimierz Parachoniak, The Microscopic Analysis of Ceramic Microsections from Works of Art /"OZ" 1967,3/ ; Krzysztof Płochocki, An Apparatus for the conservation of Paper with Paper Pulp Executed in the Department of Painting Technology and Techniques at the Academy of Fine Arts in Kraków /"OZ" 1969,4 /;Barbara Bosowska, The Employment of a Plexiglas and Duraluminium Cradle in the Conserwation of the Painting "Trzech św.Janów from Czulic /"OZ", 1965,3/ ; Józef E.Dutkiewicz, Analysis of Walls to Ascertain the State of Older Muralis /"BMiOZ" 11,1965/;Małgorzata Schuster-Gawłowska, The Analysis of /poly/vinyl acetate as Applied in the Conservation of Murals /"BMiOZ", 11,1965/;Gizela Zborowska The Reconstruction of an Alter Painting from 96 Fragments /"OZ" 1967,3/; Lidia Ramza, The Replacement of Canvas in Two--sided Paintings /"OZ" 1970,2/;Urszula Niezbyt-Woźniakowa, The Employment a Newly Constructed Stretcher for the Lining of a Painting with Steelon Chiffon /"OZ"1970,4/;Ireneusz Płuska, The Partial Removal of Deteriorated Wood from a Painted Wooden, Sculpture and Substituting it with Plastic /"OZ", 1970,2/;I.Kostow-Benczewa, The Execution of a Porous Support for the Transfer of a Wall Painting /"OZ" 1972,4/;and many others which, because of the lack of space can be listed.

Worth mentioning also are several conservation and techno-

logy handbooks published in the Kraków arèa:Jan Hopliński, The Conservation of Paintings,Kraków 1941 ; also by the same author,Painting Mediums and Pigments,Kraków 1959,and the edition of Musology,Kraków 1947 ; Stanisław Jakubowski,The Renovation of old Prints,Kraków 1947 ; Władysław Slesiński,Organic Medium Painting Techniques,Kraków 1974 ;the team research work edited by Władysław Slesiński awarded by the Ministry of Culture and Art entitled - Research Methods Employed in the Identyfication and Diagnosis of Works of Art,Kraków 1980.

Among the important works regarding theory of conservation are :Tadeusz Dobrowolski,The General Principles of Conservation,Museology,Kraków 1947 ; and by the same author,The Effects of Conservation of Art on the History of Art /"OZ" 1949,1/ ; Józef E.Dutkiewicz,Sentimentalism,Authentism,Automatism /"OZ"1961,1-2/ ;by the same author,The Limitations and Needs of Specialization /"OZ" 1963,2/.Prof.J.E.Dutkiewicz attained the titlt of "the most active theoretic in the field of conservation",though he put forward some very controversial propositions.As a result of his theoretical,practical and pedagogical work,he had a great number of students and large work team.Interesting theoretical work concerning movable art objects has been achieved by Józef Furdyna in his article, The Function of Art in the Work of the Conservator /"OZ"1970,4/, as well as in,Some Aesthetic Problems in the Theory and Practise of Conservation /"OZ" 1972,1/ ;by Tadeusz Knaus,Conservator - Technician or Artist ? /"OZ" 1970,4 / ;and by Władysław Slesiński,Reflections on the Relation of Conservation of Art to Other Branches of Education /"OZ" 1970,3/.

The problem of the documentation of examinations,laboratorial work and actual conservation have also been undertaken by Kraków conservators,and they also have considerable results in practise and theory.Examples dealing with this subject,to list but a few,are articles by : Hanna Pieńkowska,Documentation of Conservation /"BMiOZ" 11,1965/ ;Jerzy Gadomski and Władysław Zalewski,The Problems of Contemporary Graphic Documentation of the Examination and Conservation of Murals in Poland /"BMiOZ" 34,1973 / ;Władysław Slesiński,The Evolution

of the Documentation of Conservation in Poland /"BMiOZ",34,1973/. Worth mentioning is also the elaboration of the "Outline of Documentation for the Conservation of Movable Art Objects", worked out by the Instructors in the dept.of Conservation at the Academy of Fine Arts in Kraków,and obligatory now in all Poland.

Research in the history of art preservation can be represented by a few examples:Józef E.Dutkiewicz,The Achievements of Conservation in the Past Decade /"Materials for Study and Discussion ..." 1955,3-4/ and Ten Years of Art Preservation in Peoples Poland /"OZ" 1964,2/;Władysław Slesiński, Conservation Problems in Kraków in the first half of the 19^{th}c. /"OZ" 1963,1/ and The 19^{th} c. Conservation of the St.Mary's Church Alterpiece Based on a Newly Discovered Manuscript /"OZ" 1967,2/ ; An Outline of the History of Paper Conservation /"BMiOZ" 24,1969 /,Education in the Field of Conservation in the Past and Present /"OZ" 1971,2/ ; and Józef Furdyna,Problems of Polish Conservation /"Biuletyn ZPAP"1974,1/.

Kraków also is a serious research center,not only in Poland,when it comes to the history of technology and techniques.This can be reflected in the works:Maria Malanek, The Exploration of Original Plasters and Murals in the Cistercian churches of the Małopolska Area /"OZ"1968,4/ ; Józef Nykiel,The Technological Composition of Paintings on Wooden Supports from the so-called Kraków School from the Years 1420 - 1480 /"OZ" 1969,4/,and by the same author, The Technological Composition of Paintings on Wooden Supports from the so-called Sądecka School from the Years 1420-1480 /"OZ"1962,4/;Maria Niedzielska,The Technological Examination and Conservation of the Wooden Support from the Epitaph "Wierzbięty z Branic"/"OZ"1970,2/;Grażyna Korpal,The Technological Examination of Six Italian Wall Paintings from the National Museum in Kraków /"OZ" 1972,3 and 4/;Władysław Szyszko,The Technological Examination of Three Wooden Egyptian Steles from the National Museum in Kraków /"OZ" 1972,3 and 4/; Władysław Slesiński,The Technology and Painting Techniques in the Era of Romanticism /"OZ" 1966,3/,and by the same

author,On What and With Paintings were Made in the Era of Romanticism in Kraków /"OZ" 1969,2/,The Painters Studio in the First Half of the 19^{th} c./"OZ"1969,4/,A Few Commenst on the Contribution of the First Half of the 19^{th} c. to Painting Techniques /"OZ"1970,4/.

Diploma research work of much value has been done students pertaining to the technology and techniques,in art work under the direction of the author of this article.Some works awarded by the Ministry of Culture and Art:K.Wójcik,The Technology and Techniques of Ceiling Beams from the 16^{th}-18^{th} c.in the Townhouses of Kraków,1975;R.M.Wełczewa,The Examination and the Technology and Techniques of Four Icons from the City of Melnik from the Renaissance in Bulgaria,1977;A.Kozak,The Technology and Technique of Sgraffito in Southern Poland,1977; Z.Lelek,The Examination of Enamels from the Renaissance and Baroque Eras in Poland,1977:,E.Łuka,Experiments in the Search of Optimal Means for the consolidation of Pastels,1978; C.Roger,The Technological Characteristics of Some Romanesque and Gothic Mortar Samples Based on Petrographic Microscopic Analysis,1978;L.Rudek,The Technology and Techniques of Mediaval Drawings and Manuscripts on Parchment and Methods of their Identification,1978,E.Hanusz,The Examination of the Technology and Techniques of European Lacquer Ware,1979; M.Gołąb,The Utilization of Photography in 19^{th}-20^{th} c.Paintings,1980;W.Kozak,The Examination of Cradling Constructions in Easel Paintings,1980;A.Jesinowicz,The Examination of Ivory Sculpture and Attempts to Date It,1980.

Aside from the research work done and the consequent realization of this work,it also necessary to acknowledge the participation of conservators from Kraków in conference meetings,their contribution to the expansion of conservation periodicals,and their propagation of conservation.

Conservators from Kraków played an important role in the development and expansion of the one specialist periodical pertaining to conservation of art in Poland.The first editor of "Ochrona Zabytków" was Prof.Dr J.Dutkiewicz in the years 1948 - 1950 and 1961 - 1968,and the periodical was edited

from 1968 to 1973 by Prof.Dr W.Slesiński.From this time "Ochrona Zabytków" has been a specialistic professional journal,informing of accomplishments in the technology and the techniques of conservation,creating a possibility to examine the development of conservation,and also supplying material for the education of conservators.A great number of articles and information appearing in this periodical was written by conservators from Kraków.

Worth noting are also the efforts of our conservators in the propagation and popularization of art preservation.The first attempts to warms social opinion to art preservation was the popularization of the conservation of the altarpiece by Wit Stwosz in St.Mary s Church.In the past few years many discoveries and conservations have been publicized on account of the revalorization campaign of Kraków.

Publications by our conservators have also stirred up interest and popularized the idea of art preservation,for example:H.Pieńkowska,The Problems of Art Preservation in the Province of Kraków,Kraków 1974.Also playing an important role are interviews,radio and television programe,lectures and exhibitions,such as:The Exhibition of 15 Years of Conservation Education in 1964,The Conservation Exhibition on the 150 th Jublee of the Academy of Fine Arts in 1969, Theories and Practise in the Conservation of Art in 1971, The techniques of Painting and Graphic Arts in 1971,Some Problems in the Preservation and Conservation of Art Objects in 1973,The Exhibition of Dyploma Work by Students of Conservation 1973 -1974 at the Art History Association and finally the yearly exhibitions of student work in the dept.of Conservation at the Academy of Fine Art.

If the notion of a "conservation school" can be sumed up by the comprehension of such factors as:1/the number of qualified conservators with specialized education,2/the quantity and quality of restored works,3/a group of people having the same attitude towards conservation and art objects,4/the working methods not inferior to the best in this field, 5/active participation in research programs,6/the existance of an orginized educational system,one can safely state that the participation of the Kraków area,in the conception of the "Polish school of conservation"is substantial.

81/11/7

LES PROBLEMES DE LA RETOUCHE, DU COMBLEMENT DES LACUNES ET DE LA COPIE DES PEINTURES MURALES EN URSS

I. Gorine

Comité pour la conservation de l'ICOM
6ème Réunion triennale
Ottawa 1981

Groupe de travail: Théorie et histoire de la restauration

LES PROBLEMES DE LA RETOUCHE, DU COMBLEMENT DES LACUNES ET DE LA COPIE DES PEINTURES MURALES EN URSS

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L'auteur a pris pour sujet du présent rapport les problèmes se trouvant en corrélation et mûris depuis longtemps dans la théorie et la pratique de restauration à savoir, le problème de la retouche, ceux du comblement des lacunes des peintures murales et de la copie.

A la suite d'une large expension de la restauration en URSS, l'échelle des travaux de restauration des peintures murales, et par conséquent celle du comblement des lacunes se sont élargies. En 1968 à Moscou s'est tenue une Conférence nationale sur les principes théoriques de restauration des icônes, organisée par le Laboratoire central d'alors. Après une large échange de vues la Conférence a élaboré et adopté une résolution sur les méthodes de restauration des peintures russes anciennes, et notamment sur les principes du comblement et de la retouche des lacunes.*

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* Les principes théoriques de restauration des peintures russes anciennes ont été présentées à la Conférence internationale du Comité pour la conservation de l'ICOM qui s'est tenue en 1978 à Zagreb (Yougoslavie). Le rapport est publié dans les préprints.

Les méthodes de restauration des icônes ayant pour base les principes admis dans la pratique nationale en 1917-1923, qui ont été précisées à la Conférence, se trouvent aujourd'hui à la base du travail des restaurateurs soviétiques.

Dix ans après la conférence de 1968, l'Institut national de recherches scientifiques pour la restauration (ancien VCNILKR) en commun avec le Conseil scientifique et méthodique pour la protection des monuments historiques et culturels du Ministère de la culture de l'URSS ont organisé en 1978 une conférence dans la vielle ville de Novgorod, et en 1979 - une autre conférence dans la capitale de la Géorgie - la ville de Tbilissi. La Conférence de Novgorod a été consacrée aux problèmes généraux de restauration des peintures murales, celle de Tbilissi a porté sur les problèmes de la retouche, du comblement des lacunes et de la copie des peintures murales. Ces conférences ont été une sorte de synthèse de l'expérience des années passées et une suite de la discussion de l'année 1968.

Il est à noter tout de suite que le problème du comblement des lacunes des peintures monumentales en raison de la diversité des monuments, leur état de conservation, leur situation géographique, apparait encore plus compliqué que celui des peintures de chevalet russes anciennes (icônes). A l'intérieur de ces problèmes il y a beaucoup de points de contact, les principes et les procédés sont en grande partie communs et semblables, mais il y a encore d'avantage de différences, ayant une signification de principe.

En URSS ce problème est résolu par des moyens différents en fonction du monument concret, des appréciations des restaurateurs et des résolutions des commissions de restauration, qui déterminent en fin de compte la tâche, effectuent le contrôle sur la marche des travaux et approuvent les travaux achevés. Il n'existe aucune désigna-

tion méthodique précisement formulée et commune, aucune recommendation stricte sur les problèmes de la retouche, des additions à la peinture d'auteur et des reconstitutions. Cette conception existe toujours dans la conscience et les mains des restaurateurs, elle se forme au cours de l'étude du monument et est ensuite inscrite dans le procès-verbal.

Les fresques du XII siècle de la cathédrale de la Transfiguration - St Sauveur du monastère de Mirijsk à Pskov, celles de l'église du St Sauveur sur Il'ine, de F.Stratilate et S.Radonejsky des XIY-XY ss. à Novgorod, les peintures murales des XVII-XVIII ss. dans la cathédrale de la Trinité de la Laure à Zagorsk, les fresques des XII-XV ss. et les peintures murales du XX siècle dans la cathédrale de la Dormition à Vladimir, les peintures murales de l'église de Kirillov et du St Sauveur sur Bérestov à Kiev, la reconstruction des peintures de Gour-Emir à Samarkande, les oeuvres D'art archéologiques de l'asie Centrale - Varakhcha, Afraciabe, et celles de la Russie - des villes de Smolensk, de Pskov et de Novgorod -peuvent servir d'exemples de l'approche différente et variée au problème des retouches, du comblement des lacunes et des reconstructions.

Il est à noter que la restauration d'aujourd'hui des monuments historiques et culturels en URSS, malgré son organisation nationale rigoureuse et logique souffre cependant de l'approche subjective. Il arrive parfois que la volonté personnelle et les convictions du restaurateur expérimenté s'avèrent dominantes dans la résolution des problèmes de principe de la retouche et du comblement des lacunes. D'autre part il faut remarquer, que dans la pratique de restauration contemporaine avec l'intervention active et le contrôle de la part des commissions de restauration, cette approche subjective disparait progressivement et devient peu probable. Pour assurer les résultats acquis nous proposons pour l'avenir des mesu-

res excluant l'approche subjective, fondée sur les goûts, conceptions et inclinations personnelles. L'accroissement du rôle et de l'autorité des commissions de restauration, le contrôle d'Etat sur l'exécution des travaux est une des mesures prise dans cette direction.

D'autre part, nous avons inclu dans le plan de nos recherches scientifiques l'élaboration des méthodes et des principes de la retouche, du comblement des pertes, des reconstructions des peintures murales et les problèmes de la copie. Ce groupe de travail devra mettre au point les principes théoriques et les méthodes communes et concrètes conformement aux différets groupes et types des monuments et le degré de leur conservation. Cependant aucune théorie ne pourra pas prévoir et resoudre toute la diversité de tâches qu'on rencontre dans la pratique, élaborer des recommendations précises pour toutes les éventualités de la vie. Des années des travaux nous ont prouvé que dans la restauration des peintures, et surtout dans le problème du comblement des lacunes et dans la reconstruction chaque oeuvre d'art exige une approche individuelle. Mais chaque approche individuelle est possible uniquement sur la base des principes et des règles méthodiques communes. Ainsi, il est nécessaire d'élaborer des recommendations strictes quant aux monuments, aux oeuvres d'art, sur lequelles on peut faire des additions et des reconstructions. Il faut élaborer le système des retouches, leur corrélation avec la peinture d'auteur et, ce qui est également important, mettre au point les principes de l'exposition des peintures, des additions conventionnelles en tenant compte de l'aspect esthétique de l'oeuvre, de sa perception par les visiteurs. Les retouches, les additions, les reconstructions doivent être argumentées scientifiquement.

Les spécialistes soviétiques connaissent les procédés de la retouche et du comblement des lacunes, utilisés dans les pays étrengers. Dans son ensembles ils sont

les mêmes que ceux utilisés par les restaurateurs soviétiques. Ils n'ont pas eux-aussi de règles communes et de critères d'estimation, ils ne sont pas dépourvus de l'approche subjective qui est le plus ressentie là, où les travaux de restauration sont effectués sans contrôle de la part des commissions de restauration.

Aujourd'hui en URSS les procédés des retouches, du comblement des pertes et des additions peuvent être divisés en deux directions différentes. Il convient de déterminer la première comme historico-archéologique. Cette direction suppose le refus complet des additions et des retouches,même des plus élémentaires. On laisse intact chaque centimètre des peintures originales. Cette approche est strictement scientifique et sert avant tout aux objectifs historiques, de critique d'art et scientifiques. Elle ne trouve pas d'objections de la part de ceux qui apprécient avant tout l'autenticité histirique de l'oeuvre. Par contre, elle n'est pas justifié par ceux qui se prononcent pour l'intégrité de la perception artistique et esthétique de l'oeuvre d'art.

Le dégagement des fresques du XII siècle de la Cathédrale de la Transfiguration-St Sauveur du monastère de Mirojsk de la ville de Pskov peut servir d'exemple de l'approche historico-archéologique. La commission de restauration du Ministère de la culture de l'URSS, ayant constaté que les peintures du XII siècle dégagées de dessous des repeints de la fin du XIX siècle se trouvent relativement en bon état, a formellement interdit les retouches et ne s'est pas trompée dans sa décision. Il faut remarquer, que la première intervention dans la peinture du tambour et des pendatives de cette cathédrale , ayant comme résultat les retouches denses, rapprochées au maximum à la peinture originale, n'a pas réussi, elle défigurait la peinture du XII siècle. Cette première intervention sur l'oeuvre n'est devenue ni historico-archéologique, ni expositionnelle et reconstructive, si l'on

comprend cette méthode comme historico-documentaire.

J'appelerais la deuxième direction du comblement des lacunes comme historico-reconstructive ou bien expositionnelle-reconstructive. Elle existe toujours, admet des retouches, additions, reconstructions pour garder l'integrité d'impression, la clarté de représentation de l'importance iconographique du monument dans le passé. Mais c'est justement cette direction qui est le moins élaborée. Les points de vue sur le comblement des pertes sont tout à fait différents, ils se manifestent dans la pratique d'une manière différente, et dans la théorie il n'existe point de décisions généralisatrices.

Cela va sans dire que chaque oeuvre d'art exige une approche individuelle. Par exemple, la peinture ornementale du monument unique de Samarkande - Gour-Emir, est reconstruite complétement. Dans ce monument les restaurateurs n'ont pas été influencés par le poids du passé, car il n'y avait presque plus de restes des peintures originales. Ainsi, la tâche n'a pas été trop compliquée.

Une autre décision, beaucoup plus compliquée et importante a exigé la peinture des XVII-XVIII ss. de la cathédrale de la Trinité du XV siècle de la Laure de Zagorsk, se trouvant non loin de Moscou. Premièrement, il y avait des compositions entières bien conservées, deuxièmement, une grande surface des peintures était détruite, mais les dessins gravés restaient intacts, troisièmement, il n'y avait plus ni peintures, ni dessins gravés, et finalement, il s'agissait de la Cathédrale en service, appartenant à la Patriarchie, et c'était elle - même qui a fait une demande de restauration et a déterminé en quelque sorte les conditions de restauration en se basant sur le principe de la perception du monument par les croyants et les visiteurs. La commision de restauration ne pouvait pas négliger les souhaits de la Patriarchie. Lors de la restauration des peintures de cette Cathédrale on a appliqué la méthode de la reconstruction

complète sans dommage à la peinture d'auteur. Le comblement des pertes a été fait selon le principe du rapprochement maximal à l'original. Les restaurateurs ont pu démontrer le caractère iconographique des peintures, l'importance du monument dans le passé, ils ont gardé l'integrité de la perception de l'oeuvre. Beaucoups de travailleurs de la culture, y compris du milieu des spécialistes, se prononcent aujourd'hui pour cette méthode. La peinture fragmentaire historico-documentaire, si elle n'est pas expositionnelle et perceptible, ne les satisfait plus. On ne peut pas nègliger ce point de vue. Cependant le problème demeure toujours.

Cette question sera litigeuse par rapport à la restauration des peintures se rapportant à des époques différentes, par exemple celles se trouvant dans la cathédrale de la Dormition de la ville de Vladimir. La peinture originale du XII s. et la peinture de A.Roublev faite en 1408 ont été restaurées après une étude approfondie et avec le maximum de précautions selon le principe de l'approche historico-archéologique: la peinture mauvaise du XX s. a été repeinte de nouveau sans aucune rapprochement à la peinture ancienne, sans "patine de restauration", la sculpture de l'iconostase a été dorée et ses pertes reconstituées à nouveau.

Mais avec celà tout un nombre de spécialistes estime, que l'intervention trop courageuse du restaurateur contemporain dans les pertes de la peinture d'auteur, les tentatives de reproduire ou de répéter l'auteur dans le désir de complaire à la perception des spectateurs cause un dommage irrémédiable à l'oeuvre d'art, altère son caractère authentique et l'originalité historique. La reconstruction de la peinture sur le monument lui-m même, disent-ils, porte comme le mal inévitable la perte de la force de persuation de l'oeuvre en général. Les références sur le caractère canonical des peintures de culte pour justifier les reconstitutions ne sont pas

convaincantes et sont nuisibles, car le canon, le statut - ce n'est pas quelque chose d'immobile. La méthode de "l'aide" active au monument est desapprouvée. La reconstruction de grandes parties manquantes de l'oeuvre doit être effectuée non pas sur le monument lui-même, mais dans la copie seulement.

En examinant ces directions tout à fait contraires, nous devons élaborer et recommender des principes communs, choisir et proposer des méthodes, des approches qui pourraient satisfaire les exigeances de la restauration s scientifique et la perception esthétique de l'oeuvre. Les points de vue extrêmes, comme partout d'ailleurs, ne sont pas acceptables. Nous avons déjà dit, que chaque oeuvre exige une approche individuelle au problème du comblement des pertes en fonction du caractère de l'oeuvre, son état de conservation, le temps de sa création, son importance historique, artistique ou commémorative. Certes, chaque principe ne peut pas être suivi à la lettre, mais il faut avoir des principes communs et les propositions générales argumentées qui serviraient de base pour les travaux de restauration. Sans ces recommendations, obligatoires pour l'exécution, nous risquons engendrer une anarchie dans le choix de la méthode.

L'ensemble des procédés, des méthodes de restauration joue un rôle déterminant dans le problème que nous examinons. Il devront trouver leur place dans nos études. Il s'agit des problèmes particuliers du traitement de petites et de grandes pertes du plâtre et de la couche picturale, du choix des couleurs, de la densité et de la forme des retouches, du felief de la surface des peintures, de la révélation de la qualité des peintures en provenance des fouilles archéologiques, des problèmes de la reconstruction de ton et de contour, etc. Il y a beaucoup de bons et de mauvais exemples de résolution de ces problèmes.

La résolution correcte scientifique, esthétique et

technique des questions de restauration, que j'ai appelées comme "particulières", signifie dans l'ensemble la résolution juste du problème de restauration pour la réconstitution des peintures en général. Il faut répéter également cette règle bien cunnue, mais qui malheureusement n'est pas appliquée partout, que le comblement des lacunes du plâtre, de la couche picturale, les retouches, les reconstructions doivent être précédées par des études à l'aide des méthodes analytiques complèxes des sciences exactes. Les recherches pareilles aident les restaurateurs dans leurs études de l'integrité des peintures, dans la révélation de la couche picturale d'auteur, des renouvellements, des repeints, des traces des restaurations anciennes, des dessins de contour, des restes des images.

Maintenant adressons-nous au deuxième thème ou sous-thème du rapport, - le problème de la copie. La copie de l'oeuvre d'art, comme c'était prouvé avec toute la force probante par l'histoire de plusieurs siècles (rappelons à titre d'exemple les copies romaines des originaux grecs) remplit tout un nombre de fonctions les plus importantes et absolument nécessaires pour l'art et la culture.

La copie - c'est un des moyens de la protection de nos conceptions sur le monument qui, par différentes raisons n'est pas parvenu jusqu'à nos jours, ou qui est parvenu, mais dans un état altéré, endommagé. La copie - c'est une des formes de l'étude effective de l'oeuvre, elle fait accessible le monument inaccessible pour l'observation, rend un service inappréciable aux chercheurs, aux éditeurs, joue le rôle de document, peut remplacer l'original aux expositions.

Les copies sont particulièrement importantes dans [illegible], qui parmi les autres oeuvres d'art sont les plus exposées au vieillissement et à la destruction. Elles sont utilisées pour la documentation du processus de restauration, pour la recher[illegible]

l'aspect expositionnel de l'oeuvre, pour la précision de nos notions fort imparfaites de l'aspect et du caractère authentique de l'original. La copie systématique aidera par la suite à améliorer le système des principes de la retouche et du comblement des pertes sur les oeuvres originales, car lors de l'exécution des copies le peintre-restaurateur étudie de plus près l'original, la structure physico-mécanique des couches picturales, la régularité de sa composition. Il manque aujourd'hui aux restaurateurs, occupés plus spécialement de la stabilisation et de l'enlèvement, il leur manque justement de la pratique artistique dans le domaine de la copie, du tact au cours de l'intervention dans l'essence artistique de l'original. La copie systématique doit devenir une école du perfectionnement artistique et esthétique, un moyen pour mieux et plus profondement concevoir la nature artistique et technico-technologique de l'original. Au fur et à mesure de ce perfectionnement apparaitrons sans doute des conditions pour une approche plus justifiée aux comblements des pertes, aux retouches, aux reconstructions.

Il n'y a pas besoin de parler longtemps des autres tâches importantes de la copie. Certains monuments sont restés aujourd'hui uniquement dans les copies. Ce ne sont que les copies des expositions ambulantes qui peuvent fournir aux millions de spectateurs la possibilité de voir les oeuvres difficilement accessibles.

En ce qui concerne le problème de la copie et celui du comblement des lacunes, nous nous proposons d'élaborer des recommendations ou des règles communes et d'examiner les questions du droit de la copie, de la destination des copies, des procédés de leur exécution, des matériaux, les problèmes de conservation, d'exposition, etc.

Le temps est venu pour organiser un service spécial de la copie. Cela est devenu une préoccupation de l'Etat. Des musées, des monuments d'architecture, des expositions ont besoin des copies. Pour organiser un service pareil

il faut avoir des spécialistes qualifiés. Pour le moment nous ne disposons que de quelques personnes expérimentées dans ce domaine. De ce fait il faudrait charger les instituts d'art s'occupant de la formation des cadres de restaurateurs d'introduire dans leurs programmes d'enseignement le cours entier de la copie des oeuvres d'art, la copie qui ne serait pas formelle, visant à atteindre une ressemblance extérieure, mais la copie faite dans le matériel et la technique de l'original.

Certes, aujourd'hui nous ne pouvons pas prétendre à la résolution définitive des problèmes qui ne sont point généralisés et sensés sous tous les rapports, concernant les comblements des lacunes, les retouches, les reconstructions et les copies des peintures murales. Mais nous disposons de l'expérience, des conclusions préliminaires et des forces scientifiques nècessaires pour la première généralisation sérieuse et l'analyse de ces problèmes.

81/11/8

UN RESTAURATEUR ROMAIN: PIETRO PALMAROLI

S. Bergeon

Comité pour la conservation de l'ICOM

6ème Réunion triennale

Ottawa 1981

Groupe de travail: Théorie et histoire de
la restauration

UN RESTAURATEUR ROMAIN: PIETRO PALMAROLI

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Pietro Palmaroli s'est rendu célèbre par le détachement en 1809, à la demande du gouvernement français de Rome, de la fresque de Daniele da Volterra représentant la déposition de Croix dans l'Eglise de la Trinité des Monts. Après la chute de Napoléon en 1814, P. Palmaroli travaille à Rome pour le Pape avant que sa notoriété ne le fasse appeler en consultation, en 1826, à Dresde où Carl Christian Vogel von Vögelstein a éxécuté un dessin qui nous conserve ses traits (1) ; il meurt à Rome en 1828 à l'age de 61 ans.

-:-:-:-

Pietro Palmaroli "rilevatore"

Le mot italien "rilevatore" sous lequel on rencontre Pietro Palmaroli dans les dictionnaires du XIXème siècle (2) signifie artisan capable de transporter, sur toile en général, les peintures peintes sur mur ou sur bois.

On peut ne pas être d'accord avec le détachement des peintures murales et la transposition des tableaux mais il faut reconnaître l'importance historique des techniques de dissociation de l'oeuvre et de son support : période expérimentale à Naples (3) et Crémone (4) vers 1720, grand développement probablement de la technique rapide du "strappo" en Italie à partir du milieu du XVIIIème siècle, diffusion en Europe, puis perfectionnement technique avec la mise au point d'une méthode plus respectueuse de l'état de surface le "stacco", probablement à Rome au début du XIXème siècle (5).

Le travail que P. Palmaroli a mené en 1809 sur la <u>Déposition de Croix</u> de Daniele da Volterra à la Trinité des Monts de Rome est bien connu grâce au rapport qu'il fit lui même en 1810 au Secrétaire Général de l'Académie de Saint Luc pour le mettre au courant de sa technique : (6) il a enlevé du mur la totalité de "l'intonaco", l'enduit épais qui contient la couleur, et mis la composition sur toile à l'aide d'une colle de cuir de boeuf ; on peut confirmer à l'examen visuel de la composition, actuellement de nouveau à la Trinité des Monts, que l'état de surface n'est pas celui d'une couche picturale mince qui aurait pris la texture du support de toile sous-jacent : le respect de l'état de surface d'une peinture sur mur est relativement satisfaisant malgré les larges ondulations ; c'est peut-être l'une des premières descriptions d'un "stacco".

Ce rapport du restaurateur est très précieux car il précise aussi qu'il éxécute une retouche particulière à "l'encausto", à base de cire, qui ne noircira pas comme l'huile, qui ne sera pas brillante comme la retouche au vernis, et qui ne sera pas altérée par l'humidité. Il semble de plus qu'il ait enduit de cire l'ensemble de la fresque pour protéger les couleurs de l'action destructrice de l'humidité.

Un peu plus tard entre 1816 et 1820, Pietro Palmaroli va détacher trois compositions de Dominiquin peintes dans la loggia del Giardino au Palais Farnèse : <u>Vénus et Adonis</u>, <u>Narcisse à la source</u> et <u>La mort d'Hyacinthe</u>.

<u>Palmaroli restaurateur de tableaux de chevalet</u>

Un second texte très précieux de sa main date de 1819, et concerne la restauration qu'il fit du tableau, sur bois représentant la <u>Sainte Famille</u>, peint par Giulio Romano et se trouvant dans l'Eglise de Santa Maria dell' Anima à Rome (7).

Palmaroli a remplacé le bois "pourri" par du bois neuf vieilli mais il ne connait pas très bien le bois et au lieu de laisser le bois libre comme le préconise Louis Hacquin dès 1770 à Paris (8), il met au revers du panneau trois grosses traverses transversales collées et de plus vissées au tableau ce qui ne manquera pas de causer plus tard des fentes du bois. Il a, dit-il, rempli les cavités avec du gesso de doreur, et exécuté une retouche qu'il estime devoir être strictement limitée à la lacune : c'est peut-être cette qualité qui a fait apprécier Palmaroli car l'oeuvre avait été pré-

cédemment confiée au peintre Rauch (élève de Maron) qui l'avait alourdie et plus anciennement ce célèbre tableau de G. Romanc avait été, après inondation, abondamment repeint par Carlo Saraceni (1580 - 1620). P. Palmaroli va faire retrouver à ses contemporains l'oeuvre du XVIè siècle en la débarassant de ses repeints eten ne restaurant que les lacunes.

Son travail a fait l'objet d'une analyse précise en allemand en 1826 et 1827 par Quandt (9) et bien après sa mort, en 1870 par Zahn (10) un rapport sur la Madone Saint Sixte de Raphaël à Dresde a bien défini que P. Palmaroli avait éxécuté une retouche a "punteggiatura", caractéristique de sa méthode qui consiste à rétablir les passages par un travail en pointillé au lieu des larges et longues touches de pinceau de restaurateurs moins scrupuleux.
Dans le texte de Quandt de 1826 et 1827 il est précisé que P. Palmaroli préfère le nettoyage mécanique à sec, au scalpel, controlable à tout moment par rapport au nettoyage chimique au solvant qui risque d'araser les crètes des empâtements et de laisser crasse et vernis dans les creux ; certains de ses contemporains ont critiqué cette méthode à sec car par un travail au scalpel on peut ne pas respecter l'écriture picturale, casser les lignes de crasse dans les creux et conférer un aspect uniforme pointillé, velouté, qui évoque la lithographie ce qui ne serait guère surprenant à cette époque néo classique tardive, vers 1820. D'ailleurs la conception du travail de P. Palmaroli est très proche de celle de Giuseppe Zeni (1788 - 1835) restaurateur-pharmacien qui travaille à Padoue et écrit un long mémoire en 1813 (11) : lui aussi préconise le nettoyage à sec et lui aussi fait ses retouches à "l'encausto".

Carrière de Pietro Palmaroli

Le détachement des fresques permet à la fois de sauver une peinture quand l'édifice va s'écrouler ou être détruit mais rend aussi autonomes des oeuvres qui autrefois étaient par essence de caractère immobilier.

L'occupant français de Rome depuis la conquête d'Italie avec Bonaparte jusqu'à la chute de Napoléon en 1815 a pu mener à la fois une politique de conservation des chefs-d'oeuvre tout en étant tenté d'ajouter aux conquêtes artistiques du Traité de Tolentino en 1798 certaines oeuvres qui, détachées de monuments, pourraient dorénavant voyager et prendre le chemin de Paris (12).

L'histoire de la fresque représentant la Dépo-

sition de Croix peinte par Daniele da Volterra à la Trinité des Monts est significative à cet égard : en 1806 voulant sauver l'oeuvre du salpêtre et sur le conseil d'experts italiens Vincenzo Camuccini et Pietro Palmaroli le gouvernement français de Rome confie le détachement de l'oeuvre à Pietro Palmaroli qui l'éxécute entre Février 1809 et Avril 1812 ; dès Mai 1809 la fresque est souhaitée à Paris pour l'inauguration en 1810 du Musée Napoléon mais le restaurateur ne semble pas avoir fini à temps ou voulu finir son travail ; l'Empire tombe en 1815, l'oeuvre reste à Rome et fut replacée à la Trinité des Monts ; Chateaubriand en 1828 demandera de nouveau, mais sans succès, que l'oeuvre aille à Paris en essayant au nom du Roi de fléchir les Dames du Sacré-Coeur qui occupent depuis peu de temps le couvent de la Trinité à Rome.

Le restaurateur P. Palmaroli, qui pouvait détacher des fresques et servir les intérêts de la France, a été apprécié et a beaucoup travaillé dans les milieux français de Rome : pour le Cardinal Fesch à Santa Maria della Pace il a détaché La Visitation de Sebastiano del Piombo ; en 1811 il a même son atelier installé dans le Palais de France au Corso ; pour Lucien Bonaparte il a restauré La Madone aux Candélabres de Raphaël (actuellement à Baltimore) et Le Christ devant Pilate de G. Honthorst (actuellement à la National Gallery de Londres). A cette époque il a restauré à Sainte Marie des Anges Saint Sébastien peint par Dominiquin et Saint Jérome par Muziano. P. Palmaroli a aussi connu d'autres milieux étrangers de Rome, les amateurs anglais Lord Kinnaird et Jacques Irwin, pour ce dernier il a restauré La Bacchanale du Titien (actuellement à Prado) ; il a travaillé pour Charles IV, Roi d'Espagne en exil ; sa renommée est grande déjà en 1815 puisque lors du retour de Paris à Madrid des tableaux pris en Espagne par les français, les autorités espagnoles souhaitent que l'on prenne avis du célèbre restaurateur Palmaroli (13).

Après le chute de l'Empire, Pietro Palmaroli travaille pour le Pape, il restaure au Quirinal un Saint Sébastien peint par Titien ; il est nommé auprès de V. Camuccini, ce dernier chargé de l'Inspection des Peintures Publiques de Rome. On rencontre des travaux éxécutés régulièrement par P. Palmaroli sur les peintures murales des Eglises de Rome de 1814 à 1818:
de septembre 1814 à Juin 1815, à San Gregorio del Celio il restaure Le Concert d'Anges et Saint Adré Martyr peints par Reni La Flagellation de Saint André par le Dominiquin, d'Aout 1815 à Mars 1817 il restaure à Santa Maria della Pace Les Sibylles de Raphaël, Les Prophètes de Timoteo Viti, à Sant Agostino Isaie par Raphaël ; d'Aout 1817 à Juin 1818, il restaure à San Pietro in

Montorio La Flagellation de Sebastiano del Piombo, à Santa Maria del Popolo, La Nativité de Marie par Sebastiano del Piombo, à Saint Clément, L'Histoire de Sainte Cécile par Masolino da Panicale.
En 1820 il restaure au Vatican Les Stances de Raphaël, entre 1818 et 1823 il restaure à la Trinité des Monts Le Christ jardinier et La Madeleine attribué à G. Romano (tableau peint plutôt par Cesare da Sesto).
En 1822 il restaure le tableau représentant Saint Augustin peint par Guerchin qui vient de San Pietro in Vincoli.
A des dates que nous ne connaissons pas il a restauré les peintures murales de Sodoma de la Farnesina (Alexandre et Roxane ; Alexandre sous la tente de Darius), à Saint Jean des Florentins il a restauré trois tableaux à l'huile sur bois de Cigoli Vie de Saint Jérome et Saint Jérome regardant le fronton de l'église par Passignano, à Sainte Marie des Victoires La Vierge et l'Enfant avec Saint François, huile sur toile par Dominiquin enfin à Saint Louis des Français les trois tableaux de Caravage, peints à l'huile sur toile représentant L'histoire de Saint Mathieu ; il a aussi remis en état une Vierge à l'Enfant peinte à fresque par Pierre de Cortone à l'extérieur sur l'abside de Santa Maria della Consolazione.

Pietro Palmaroli est un restaurateur réputé, la qualité de son travail est bien connue à Rome, il a même écrit un livre en collaboration avec le chimiste L. Marcucci en 1813 (14), et il est connu des étrangers qui passent à Rome ; cité par Goethe il sera appelé par Carl Auguste de Saxe à Dresde où il restaure onze tableaux célèbres entre 1826 date où il est appelé et 1828 époque où il meurt à Rome : Une Madone par Garofalo, transposée de bois sur toile et détruite en 1945, La Famille d'Alphonse 1er de Ferrare et Le Denier du Christ par Titien ; Marsyas et Midas par P. Bordone ; Le médecin du Corrège, La Madone Saint Sixte par Raphaël, Vénus et l'Amour de G. Reni, Un Ecce Homo d'après Raphaël, par Penni perdu en 1945 ; un autre Ecce Homo par Moralès, Jacob et Rachel par Giorgione enfin La Nuit du Corrège. Nous ne connaissons pas son travail sur chaque tableau car les rapports de restauration ont fait partie des archives de Dresde détruites en 1945 mais l'analyse de Quandt date de cette époque et rend compte des qualités de Palmaroli et de sa manière de travailler.

Le métier de restaurateur devient autonome et spécifique au XVIIIème siècle mais ce n'est qu'au début du XIXème siècle que les principes d'action sont clairement exprimés dans des textes tels ceux techniques et précis de Pietro Palmaroli ou ceux de ses

contemporains Giuseppe Zeni à Padone (1818) et Pietro Edwards à Venise (1819).

(1) Dessin éxécuté le 12 Aout 1826 ; H. 293 mm x L. 227 mm Kupfertischkabinet Dresdem C 3281

(2) NAGLER G.K. Kunsterlexicon, München, 1835

(3) CAGIANO de AZEVEDO, Michel angelo : Una scuola napoletana di restauro nel XVII et XVIII secolo Bollettino dell' Istituto Centrale del Restauro 1950

(4) GIORDANI Gaetano Cenni sopra diverse pitture staccate dal muro e trasportate su tela e specialmente di una grandiosa con maestria eseguita da Guido Reni, Bologna, 1840.

(5) BERGEON Ségolène Contribution à l'histoire de la Restauration des Peintures en Italie au XVIIIème siècle et au début du XIXème siècle, Mémoire Ecole du Louvre , Juin 1975.

(6) GUATTANI, Mémorie encyclopédie romane Roma 1810, Vol. 5.

(7) Giornale arcadico di Scienze ; lettere ed arti : Restaurazione di un quadro di Giulio Romano, Tome III Luglio Agusto Settembre, 1819, Roma.

(8) Parquet coulissant éxécuté au revers de la Kermesse de Rubens, en 1770 par Louis Hacquin en remplacement du parquet fixe défectueux posé en 1750 par la Veuve Godefroyd. (Louvre).

(9) QUANDT, J.G.V. Artistiches Notizenblatt Herausgeber Böttiger Janvier 1827 - Février 1827 - Mars 1828.

(10) ZAHN, A von Restauration de la Madone Saint Sixte Jahrbücher für kunst wissenschaft Leipzig 1870 Tomme III

(11) ZENI, Giuseppe Dipinti restauro, Venise, Museo Correr Manuscrits Ms P.D. 307 XXX 1818.

(12) C'est pourquoi les talents de Mme Barret, française experte en détachement de fresques, ont été vantés par le Directeur du Musée Napoléon, Vivant Denon, qui la recommande à Rome où elle travaille au Quirinal et à Parme où elle ne parvient pas à obtenir l'autorisation de détacher les Corrège de l'Oratoire Saint Paul . (Archives du Louvre).

(13) MADRAZO, Mariano de Historia del Museo del Prado (1818-1868), Madrid, 1945.

(14) MARCUCCI, Lorenzo Saggio analitico chimico sopra i colori minerali con note del Sig Pietro Palmaroli restauratore di quadri antichi Roma, 1813.

(15) CONTI, Alexandro Storia del restauro, Electra Italia, 1973.

CARE OF WORKS OF ART IN TRANSIT

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P. Querejazu (Peru)

Programme 1978-1981

1. International Exhibition Organizers Manual (Cannon-Brookes, Stolow).
2. Packing systems, cushioning, and transport problems (Bos, Cadorin, Dlugatch, Dunluce, Martin-Méry, Nordqvist).
3. Environmental control and microclimate problems during exhibitions and transit (Stolow, Dlugatch, Toishi).
4. Malpractice experiences in exhibitions, condition examination procedures, and standards in care and preservation of exhibition collections (Cadorin, Cannon-Brookes, Querejazu, Stolow).

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CARE OF WORKS OF ART IN TRANSIT AND ON EXHIBITION: REVIEW AND ASSESSMENT

Nathan Stolow

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Care of Works of Art in Transit

CARE OF WORKS OF ART IN TRANSIT AND ON EXHIBITION: REVIEW AND ASSESSMENT

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Abstract

The earlier work and research interests are described for the Working Group- Care of Works of Art in Transit. This is largely done for the period since the Triennial Meeting of 1978. While there is increasing concern over the risks taken in moving works of art, not a great deal of work has been carried out within the museum field to clarify basic problems. Condition reporting is still inadequate, and little is still known about the long range effects of exhibition stresses caused by climate changes, vibration and other factors. Exhibition conservation as a separate discipline should be developed.

Introduction

The Working Group- Care of Works of Art in Transit- has reported on developments and research activities in this field for a number of years at the triennial meetings of the ICOM Committee for Conservation[1] It is one of the few Working Groups which involves both the curatorial and scientific sides of the Committee. Since its inception, the programme of this Group was envisaged to be wide-ranging in its study and evaluation of practices and standards in travelling exhibitions, considering not only the conservation aspects but also the museological issues concerned. Exhibition activity progresses and expands relentlessly, particularly loan and circulating exhibitions. Conservation standards for exhibitions have developed over the years but have not been applied consistently, and often not at all. It is still widely believed that there are too many exhibitions being organized, many for frivolous, or political reasons, and that there is much wear and tear of art objects and cultural treasures through movement, poor conditions at display centres, and inexpert handling at the various transit points. It was never the

purpose of the Working Group to resist the general trend towards the democratization and increased accessibility of cultural property through exchanges and exhibitions. Its goal, as expressed in its programme, was rather how to bring exhibition organizers and conservators together to develop standards and techniques of handling, packing, shipping, environmental norms and their maintenance; at all stages in the exhibition process. A dogmatic approach was never taken, e.g., panel paintings should never travel; but one based on study and actual experience. As it has turned out even the most fragile objects could be sent on exhibition provided the necessary control measures and packing technology was applied. In these, admittedly rarer situations, the costs would be great, and it would be necessary to involve highly specialized personnel. In the past a variety of museum specialists, and even outside experts, have contributed to the work of the Group. Thus curators, directors, registrars, museologists, as well as conservators, scientists, and transportation experts have contributed through papers, or in a consultative way. The study or research areas have included such problems as: condition reporting and evaluation of deterioration caused by exhibition activity; packing systems utilizing traditional and synthetic materials; environmental control techniques for both the transit and exhibition phases; instrumentation of potential application for determining stresses in transit (e.g., vibration, shock, abrupt climate changes); handling techniques, and related subjects. By no means have these problem areas been fully clarified. As of this date there is much work to be done, not only by the Group but by others outside of ICOM, in the technological and commercial fields.

It is to be expected that in studies of an interdisciplinary nature there would be some overlapping with projects or studies carried out in other Working Groups. Thus the Group on "Climatology and Lighting" is concerned with matters of vital interest to this Group, and perhaps other Groups dealing with specific collections (ethnographic, archeological, textiles), or with specific materials (metals, wood), have undertaken special studies which would aid the work of those involved in conserving objects on exhibition and travel. It has been clearly established that conservation protection cannot be confined to only one part of the exhibition process, as is often done for the transit phase. Beautiful packing and packing cases are devised for travel yet at either end the conditions are stressful to the objects. All stages must be controlled in order for the object or work of art to be exposed to the least risks of faulty handling, environmental variations, and other factors.

There have not been many publications and reports in this field since the Zagreb Meeting. Break-throughs do not occur at regular intervals as they appear to occur in such

areas as analytical research. The progress is characteristically slow of a multi-disciplinary field, which attempts to bridge both the curatorial and conservation sides.

Exhibition Environments

Environmental conditions, levels or relative humidity (R.H.), temperature, light (where of importance), are being specified more frequently in travelling and loan exhibitions, forming part of the conditions laid down in the loan agreement. Generally the lending institution wishes to maintain similar conservation protection, including environmental levels at the exhibition site. At times however the requested conditions are even more rigorous than those which existed in the past, which may constitute a stressful change for the loaned objects. Where the conditions obtaining in the borrowing institution are not known the lenders may request evidence of climate control to the required levels. At times too, particularly in major international loans, a site study might be made to evaluate the ability of the museum to meet the necessary conditions. At the same time security, staffing, and other administrative features of the exhibition centre might be surveyed. Reports of this nature prepared by specialists acting on behalf of the potential lender have been carried out with satisfaction to both parties; as in the preliminary studies made on behalf of the Irish authorities for the Treasures of Early Irish Art Exhibition[2], in which five major U.S. Museums were assessed. The lenders in this case specified environmental levels of 60% R.H. and 20°C, with light levels for the precious manuscripts not to exceed 50 lux. On the basis of the survey the participating institutions agreed to the construction of a portable micro-environmental (walk-in) chamber for exhibiting and housing at least the most humidity sensitive objects, e.g., the six early maniscripts. This resolved the problem of maintaining high levels of R.H. (60%) in exhibition galleries designed for lower humidity conditions. The self-contained chamber was climate controlled within by mechanical systems with fail-safe devices to maintain a 'background' environment close to the levels specified. The temperature was maintained by a refrigeration unit, and the R.H. by the alternating action of a humidifier and a de-humidifier. The manuscripts (Kells, Durrow, and others) were displayed during opening hours within acrylic cases individually controlled with preconditioned silica gel. Within the chamber there was a massive steel safe (with a high fire rating) also containing quantities of silica gel, where the MSS were stored over-night, or when not on exhibition.

A less rigorous approach to environmental control in exhibition galleries was taken in the Shakespeare Exhibition[3], which travelled through the U.S.A. In the originating institution- the Folger Shakespeare Library-preliminary

monitoring of the conditions there prior to the itinerary indicated that a suitable climate for travel and for exhibition would be between 45-55% R.H., and temperatures between 20-24°C. The light levels were required to be set at not more than 50 lux for the sensitive manuscripts, books, and paper and textile memorabilia.

In the Tut-ankh-amon Exhibition[4] humidity control was also arranged for the objects which were susceptible to R.H. variations. Cases were installed with buffering materials to control R.H. However in at least one of the centres the type of case design precluded any effective transfer of humidity from the pedestal to the vitrine.

In a loan exhibition where the objects come from various collections and differing climate exposures, it is difficult indeed for the borrowing institution to accomodate all the requested conditions, even when the display area has all the necessary equipment. A realistic solution is to maintain an average condition in the area, and to place specific objects and works of art requiring more precise levels of R.H. inside specially controlled and maintained cases. A recent application of this principle has been in the Breughel Exhibition in Bruxelles[5]. There might have to be some changes in insurance policy,as in such arrangements both lender and borrower make arrangements for maintaining the objects in stable environmental conditions. Presumably it is possible for the lender to supply a mal-functioning climate case which unknowingly causes damage to the humidity-sensitive object. It would appear here that the borrower is largely free of blame if the damage is attributable to the case climate rather than to that obtaining in the gallery proper.

In recent years more and more of the major museums and exhibition centres are setting aside areas specifically designed for temporary exhibitions. These galleries may be equipped with their own climate maintenance systems, flexible lighting arrangements, security devices, and associated storage rooms. As of this writing there is no compilation of such centres and the special exhibition galleries housed within. The method of operation of these galleries and their degree of success to meet the specifications imposed by lending institutions would be interesting to know. In at least one country, Canada[6], a survey of exhibition galleries and centres for the purpose, had been carried out, and the results (descriptions, floor plans, staffing, etc.) compiled in a useful way. Such information is of great value to exhibition organizers, curators, conservators, in planning for safer showings.

Condition Reporting

This still remains a largely under-developed area. The essential problem is to devise a report which records and

evaluates changes in the physical condition of a work of art as it moves about from one venue to another. Obvious damages such as tears, breaks, loss of material from the surface are readily recorded by photos and words, and can usually be tied in to a specific event. A tear may be the result of faulty packing, and an abraded surface may have been caused by improper storage after unpacking in an overcrowded registrar's room. Much more difficult to assess are those damages resulting from less obvious stresses, as from vibration in transit, environmental changes from point to point, variations in lighting, and at times through exposure to polluting atmospheres, as in improperly designed display cases.

Photographs taken under controlled lighting conditions, and specified film stock, are very useful for determining changes in surface of specific details of an object or work of art. An earlier study[7] proved the utility of recording at intervals the statue of cracks in a painting during the itinerary of a travelling exhibition. In the Irish Exhibition2 colour photographs (transparencies) of detailed areas of the manuscripts (particularly illuminated portions) were taken at the various exhibition centres. The photographic specifications were very precise so as to allow for comparison studies to be made at a later date particularly if it was suspected that fading action had occurred, or that some cracks had been extended.

It is noted that in the major exhibitions more attention is in fact being given to the preparation of condition reports. The lending institution usually has on file a detailed conservator's report, if not one additionally prepared emphasizing the more fragile features of the object (features which may give rise to problems during the travel circuit). The difficulty with condition reports is when various hands and eyes are involved in observing and documenting changes believed to have occurred. In travelling exhibitions cumulative condition reports carried out by various persons are very difficult to assess in the event that some damage does in fact occur. A far more satisfactory situation is when only one qualified person, e.g., the conservator who drew up the initial report, is called upon to document the condition at the various stages. If there are differences of opinion, then such reports can be appended by such persons, for later evaluation if necessary. It has also been stressed that when objects are finally returned, a terminal condition report should be drawn up, about six months later, to establish whether there has been any delayed action.
No reports or publications have been found which deals with the matter of delayed physical changes resulting from the stresses of exhibition travel and exposure.

In general the past few years have seen no fundamental improvements in condition report writing and documentation.

The camera is still very much relied upon for visual recording. Often however it is difficult to duplicate the conditions which applied when the photograph was taken, or the particular treatment of the negative at the printing stage. Much research needs to be carried out relating fragility of structures to exhibition stresses. It is generally stated that works of art and objects are worn out in exhibitions. This may be so, but there must be some objective criteria to determine how and under what circumstances this happens.

Transport Systems

The preferred method for long distance transport is by airplane, in particular by jet freighter. It is now fairly standard practice for registrars and conservators to specify pressurized and temperature-controlled stowage on board; and that if there are sufficient cases that these be placed in containers. Air line company freight officials often declare that this mode of transportation is the most secure of transportation systems in terms of accidents per distance covered per passenger. While this may be so, in an air crash the loss is usually 'total'. In spite of the reassuring statistics, it is still the practice to divide up shipments among two or more flights if the exhibition consists of extremely valuable works of art or national treasures. Damage of another sort can occur in air travel attributed to the penetration of cabin air as the ambient pressure is reduced at altitude, and then increased on landing. Cabin humidities at maximum flight altitudes have been measured as low as 5-10% R.H. This very dry air can be aspirated into packing cases at ground level pressures, and after an interval of time, outside air of quite different conditions can then be drawn into the case until pressure is equalized. There are at least two instances known to the author where damage to works of art have occurred as a result of such air exchanges[8,9].
Ship travel is less frequently used for the movement of exhibitions but in recent years there have been some improvements particularly in courier-accompanied shipments[10]. Normally ocean travel involves long transits, periods of storage at docks under changeable climate conditions, and rough handling from and into ships and connecting vehicles, lift trucks, etc.

For moderate distances, of the order of 1000 Km, road travel by van (truck or lorrie), or semi-trailer, is frequently specified for exhibitions. A number of transportation companies in the private sector have been established over the years which are specialized, in part, in the handling and movement of art exhibitions[11]. Some museums have designed their own transport trucks with interior fittings, insulation, shock absorbers, and tempera-

ture control systems. Similar vehicles, and also trailers have been built for commercial transport use. In the last few years there have been improvements in the way vehicles ride on road surfaces. Wheel and axle bases have been modified to absorb much of the shocks and vibration transmitted from the road bed[12]. It is more difficult to control R.H. in trucks or trailer bodies. While temperature control is highly desirable, particularly in extreme climate areas, R.H. maintenance is of secondary importance. The reason for this is that most cases are sufficiently well-packed with buffering material within so as to keep the interior R.H. reasonably stable, provided the ambient temperature is not too changeable, and the transit not of too long duration.

It has been mentioned[13], as a matter of principle and common sense, that a safe transit includes adequate packing according to the mode of transportation selected. If for example ship travel is selected with its expected rough handling and long periods of changeable weather, the packing case must be very strong, well insulated, and carefully designed to compensate for shock, vibration, and be water resistant. A light weight case is feasible, for example, in a hand-carried type of transportation by car; or by courier in a passenger air craft where on the adjoining seat in the cabin the case is placed.
The term 'transportation strategy' which applies here is one which exhibition organizers and registrars find useful in minimizing transit risks.

Packing Techniques

There is a steady increase in the use of plastic materials, particularly the rigid foam plastics, in packing and shipping of works of art and objects. Polyvinyl chloride foams have given way to the more stable polystyrenes, polyurethanes, and the most stable ones, the polyethylene foams (in the U.S. 'ethafoam'). These various light weight materials of excellent thermal insulation characteristics are used as thick slabs, formed and cut to fit the contours of the materials being packed, or when available in pellet, or peanut form, can be used as loose fill to take up the free space in the packing case. Various packing techniques utilizingthese plastics have been described in a recently published book[14]. It should be emphasized that a disadvantage of the various foam plastics is their low water retentativity.
This means that they hardly function as humidity buffers in the manner of the more traditional materials such as wood, plywood, paper, corrugated cardboard, and other cellulosic products (including fabrics). Warnings have been issued in the past against packing humidity sensitive objects directly against polyetylene film, which like the foam plastics has very little moisture absorbancy[15]. It is advisable to pre-wrap the object (in cocoon-like

fashion) with a moisture buffering material, e.g., soft paper, cloth, before surrounding it, or floating it in plastic materials of the types mentioned. As cases packed in this manner are very well insulated, it is also important when they are exposed to very long periods in extreme temperature conditions, not to open them at destination until they have reached ambient temperature. This may be at least 24 hours. If this is not done, the interior may be subject to serious humidity stress, or condensation, because of the temperature differences between the case core and the exterior.

Some experimental work has been carried out on case design, and selection of outer materials other than the traditional wood and plywood. Triple corrugated cardboard faced with plastic and even metal coatings are used in industry and are now being tried in smaller exhibition circuits. This material is relatively light weight, but very strong, and cases built from this can be reused a number of times if well designed with appropriate closures. At the Zagreb meeting mention was made of the specially designed polyester cases made for transporting early ecclesiastical robes (dalmatica) from Mexico to the U.S.A.[16].

Progress has been made in closing devices for exhibition cases. These are much more superior to those used in the past, and are not only reusable but offer very positive closing pressure. The devices range from nuts and bolts in captive metal plates, to clasp-like devices with quick opening mechanisms, such as used in the aircraft industry.

As regards packing systems other than those referred to[14], some interesting techniques are worth mentioning, as developed in the non-art exhibition field. Thus in the Shakespeare exhibition[3] the manuscripts and books were placed in holding devices (form fitting frames which surrounded these) mounted on horizontal sliding shelves, which were inserted into the packing cases. The lids were fixed at the open end with closing devices and gaskets to ensure a reasonable degree of air tightness.

Double case systems have been used where a high degree of shock absorbency, thermal insulation, and buffering of R.H. is required. Where such cases have been constructed of metal a good degree of fire protection (retardancy) was also obtained[17]. Because of design costs the more sophisticated of double case systems have been reserved for extremely important situations, as in the transport of national treasures, and particularly where there is extreme fragility. The subject of packing and case design is reviewed further in the next section on climate controlled cases.

<u>Environmentally Controlled Cases for Transit (and Exhibition)</u>

Conditioned silica gel has been used in a number of international exhibitions for the control of internal R.H. For short transits where the travelling cases are well sealed reasonably good control can be achieved without the use of conditioned silica gel. The packing materials, if cellulosic, can be conditioned along with the object to a certain level of R.H. and then packed into the case. The R.H. can be maintained within 5-10% of the specified level if the transit temperatures do not vary too excessively. For passages of the order of many days or weeks, and particularly if there are periods of storage at transfer points, it is advisable to incorporate additional buffering materials like silica gel, and to design the packing case in a more air-tight manner by using gaskets at the lid, and positive fastening devices. The placement of the required amount of silica gel, or similar conditioning agent, should be in a manner to expose as much as possible the gel to the interior space, (high surface area to mass of gel), and with clear air path to the object. The techniques for using silica gel in packing and display cases were discussed by the author at the Rome Conference on Climatology[18]. When it is intended to ship a humidity-sensitive object, e.g., panel painting, or parchment manuscript, it is desirable to place this first into its own R.H. controlled micro-climate display case, and then pack it into the travelling case. Special attention has to be given to shock absorbancy, and to air tightness of the outer case. As an extra precaution the outer case could also be climate controlled. Because of the greater risks to damage in transit of such packing systems they are usually courier accompanied. Reference has already been made to the Irish[2], Shakespeare[3], and Breughel[5] exhibitions where such systems were used. Another interesting transit of this kind was the shipment of a Seurat painting in its own microclimate case from San Francisco to Paris[19]; and the earlier report on the transit of an early Italian panel painting from Ottawa (Japan)[20] is also relevant.

Temperature control in transit is usually obtained by external systems. Thus the vehicle, truck, container, airplane is kept to specified levels. For transits of the order of hours, well-insulated cases can retain internal temperatures very well, depending of course on the magnitude of temperature difference between initial case temperature and the outside. Heat of fusion technology[21] has been used in the space technology industry for temperature maintenance within cases, but has not yet been applied for exhibition purposes

The monitoring of internal R.H. by means of recording hygrothermographs is rarely done. In some exhibitions humidity cards are packed along with the object or work of art. These however indicate the R.H. only at the time of observation, and do not give a continuous record as does

the hygrothermograph. Temperature indicating strips are also available, changing colour when a predetermined maximum temperature is reached. These may be used for exhibition transits to indicate the paper indicator temperature. They will record only once, and will not indicate higher temperatures which may have occurred in transit.
Since the Zagreb meetings there has not been such progress in the study of vibration and its monitoring within packing cases. Experimental studies[22,23] with instrumented cases show that this is still a useful field to develop further.

The arrangement of lighting and maintenance to acceptable levels is of great importance in the display of light-sensitive objects, but also where objects are in climate controlled cases (e.g., controlled with conditioned silica gel). In the latter, spot lamps placed too close can cause localized heating and disrupt the moisture content-R.H. balance of the object, with resulting mechanical strain. Most exhibition designers are conscious of the need to install lamps remotely from cases, but occasionally even in major exhibitions, lamps are placed within display cases subjecting works of art to thermal stresses. Unless specified otherwise most international exhibitions maintain light levels beyond 300 lux. However if the loan agreement requires levels of 100 or 50 lux for sensitive works of art this is usually arranged. In most instances the lending institutions frame drawings, prints, and similar light-sensitive works under ultra-violet absorbing acrylics as an additional precaution.

Although the relationship between equilibrium moisture content and ambient R.H. is well known for many hygroscopic materials the weighing of objects is seldom carried out as a means of verifying the constancy in exposure conditions[24].

Standards for Exhibitions; further Developments

A few significant books and special reports have been published which relate to the conservation and protection of works of art in transit and on exhibition. These range from more general museological works[25] to specific publications which cover technical aspects and standards to be maintained[14,26,27,28]. Relatively little fundamental research has been carried out in this field as evidenced by the sparcity of publications on such relevant subjects as environmental maintenance of exhibitions, vibration control, condition monitoring. There is however a growing interest in the improvement of standards for exhibitions, particularly among exhibition organizers, curators, conservators, registrars, transportation companies, and insurance agencies. Conservators are however expected to play a greater role than at the present. The development of the discipline " exhibition conservation " requires

specially trained conservators who will specialize in the conservation and technical aspects of travelling exhibitions, ranging from condition reporting, packing techniques, to environmental monitoring[29].

The need for research and technical development has been referred to at various points in this brief review of the field. There is much work to be completed, and new projects to be embarked upon. The Working Group- Care of Works of Art in Transit - can play a useful role in this regard.

References

1. The programme of this Group was first defined at the Amsterdam Meeting of the ICOM Committee for Conservation, September 1969. The last reports at the Zagreb Meeting in 1978 included papers by Cannon-Brookes (U.K.), Rojas (Mexico), Kokalj (Yugoslavia), Stolow (Canada), Toishi (Japan), and Zaitsev and Kuzmich (USSR).

2. Treasures of Early Irish Art: 1500 B.C. to 1500 A.D. This exhibition included such outstanding world treasures as two volumes of the Book of Kells, and the Ardagh Chalice. The Exhibition travelled from Dublin to New York in October 1977 and then for the next two years to other major U.S. art museums.

3. Reference is also made to the exhibition Shakespeare, the Globe,and the World which was circulated in the U.S.A. from 1979, and will travel through 1981. The Exhibition consists of rare manuscripts and memorabilia from the Folger Shakespeare Library, Washington, D.C. The travelling cases, and a number of the display cases were climate controlled with conditioned silica gel.

4. The most recent Tut-ankh-amon Exhibition travelled to the U.S.A. by ship in 1976 and was in circulation in the first phase of its travels from 1977-79 in 6 major centres. In 1979-80 the itinerary was extended to include additional U.S. and Canadian museums.

5. The Breughel Exhibition was assembled and exhibited at a large exhibition centre in Bruxelles late in 1980. Those which were on panel, or regarded as very humidity sensitive were displayed in humudity controlled display units. The Breughel panel painting from the Montreal Museum of Fine Arts was transported in its own climate controlled display case. After its return it was found that the internal R.H. remained constant throughout the entire period it was away from Montreal.

6. Directory of Temporary Exhibition Facilities in Canadian Museums. National Museums of Canada, Museum Assistance Programmes, Ottawa. 683 p., illus.

7. Wennberg, Bo. A report on preliminary study of damage to paintings during transport and temporary exhibition by means of photographic enlargement (64:1), in Report of the Working Group on the Care of Works of Art in Transit (Proceedings of the ICOM Committee for Conservation Meeting in Amsterdam, September 1969) p. 6-12.

8. A late 19th century British painting was severely damaged with extensive flaking and loss of paint after it was air shipped from Britain to Italy. Information and photographs communicated privately to N. Stolow by Mr. Timothy Stevens, Walker Art Gallery, Liverpool, and Prof. G. Urbani, Istituto Centrale del Restauro, Rome, 1978.

9. Private communication, 1978, with Mr. Gustav Berger, Conservator of Paintings in New York. A drawing on paper was ripped as a result of environmental stresses encountered in an air shipment.

10. Cannon-Brookes, P. The transportation of a consignment of paintings from Cape Town to Southampton by sea, September 1977. Preprints of ICOM Committee for Conservation, 5th Triennial Meeting, Zagreb, 1978. p.78/12/2/1 to -/12/2/5.

11. The international organization ICEFAT- International Convention of Exhibition and Fine Art Exporters- groups together the major transport companies in Europe, America, and other continents concerned with the movement of fine art. This informal organization meets annually to discuss standards, technology, and relevant administrative and technical problems in the transportation field. The last meeting of ICEFAT was held in New York, November 1980.

12. One such system is called 'Air Ride' and is used in American trucks. The shock absorbers have been specially built to absorb vibrations and most of the shocks transmitted to the wheel base from the road.

13. Private communication with Peter Cannon-Brookes, Keeper of Paintings at the National Museum of Wales, Cardiff. The concept of 'Transportation Strategy' is developed further by him in the forthcoming book (co-authored with N. Stolow) The International Art Exhibition Organisers Manual. Publication of this book is expected in late 1981.

14. Stolow, N. Conservation Standards for Works of Art in Transit and on Exhibition (UNESCO, Paris), Museums and Monuments Series, XVII, 1979, 129 p. The French translation was published in 1980. Float packing, plastics, and various packing systems are described in Chapter 3: Case design and packing techniques.

15. Stolow, N. Some studies on the protection of works of

art during travel. Recent Advances in Conservation: IIC Rome Conference 1961, p.9-12. Butterworths, London.1963.
Also see loc. cit. ref. 14, p. 84-85.

16. Rojas, A. The packing of cultural objects: three Mexican experiences. Presented at the 5th Triennial Meeting of the ICOM Committee for Conservation, Zagreb, 1978.4p.

17. loc.cit.ref.2. In the Early Irish Treasures Exhibition the outer travelling cases were of double-walled metal construction with mineral wool in the interior. It was estimated that this type of construction had a fire rating of about 1 hour.

18. Stolow, N. The effectiveness of preconditioned silica gel and related sorbents for controlling humidity environments for museum collections: a twelve year report. Preprints at the Symposium on Climate and Conservation in Museums. November 6-10, 1978, ICCROM (Rome Centre), Rome.

19. Private communication with Mrs. Teri Oikawa Picante, Conservator of Paintings, DeYoung Museum, Fine Art Museums of San Francisco.

20. Stolow,N. Environmental control during transport of an early Italian painting from Canada to Japan. p.5-14 in Report of the Conservation. Madrid Meeting, October 1972.

21. Important work in this area, for transport of space vehicle components, has been carried out at the Charles Stark Draper Research Laboratories of the Massachusetts Institute of Technology, Cambridge, U.S.A.; private communication with Mr. A.D. Hoch.

22. Marriner, P. A case history. Gazette of the Canadian Museums Association (Ottawa), Spring 1975, p. 12-16.

23. Schroeder, O.E.H. and Hamm, F.M. Art in transit. Maltechnik-Restauro. vol. 81, no.4, 1975, p. 225-227.

24. loc. cit. ref. 20. The weight of the Simone Martini panel painting was monitored and was found to be remarkably constant in its climate controlled case. Also see loc. cit. ref. 2. In the Irish Exhibition the manuscripts were weighed at the different venues to establish whether there were any basic changes in moisture content resulting from possible R.H. changes during the two year itinerary.

25. Dudley, D.H. and Wilkinson, I.B. (Editors), and others. Museum Registration Methods. 3rd. Edition, Revised. American Association of Museums, Washington, D.C. 1979, 436 P. illus.

26. Report of the Study Group on Care of Works of Art in

Travelling Exhibitions of the Museum Exchange Sub-Committee of the United States- Japan Conference on Cultural and Educational Interchange (CULCON) Japan Society, New York. 1980, 25 p.

27. loc. cit. ref. 13. The 'Manual' authored by P. Cannon-Brookes and N. Stolow will deal largely with practices and standards recommended for international art exhibitions. It is directed to a broad readership but will be of particular value to curators, conservators, and commercial specialists in the packing and transportation fields.

28. Registrars' Report. Editor, Patricia Nauert. Los Angeles, U.S.A. This journal appears at irregular intervals, but deals with subjects pertinent not only to registrars bur also to those concerned with travelling exhibitions.

29. Stolow, N. Recent developments in exhibition conservation-policies and directions. Museum (UNESCO, Paris), vol. 29, no.4, 1977, p. 192-205.

81/12/2

CONDITION REPORTING FOR MAJOR INTERNATIONAL EXHIBITIONS

Nathan Stolow

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Care of Works of Art
in Transit

CONDITION REPORTING FOR MAJOR INTERNATIONAL EXHIBITIONS

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Summary

One of the most difficult problems for both conservators and curators is the assessment of physical condition of objects and works of art before, during, and after the experience of travelling exhibitions.
Condition reports are often too subjective, open to misinterpretation by even the experts, and often omit important observations which are needed for determining the effects of environmental changes and mishandling likely to show up as 'delayed action' some months after return. Reference is made to experiences encountered in a number of recent international exhibitions, such as "Treasures of Early Irish Art", "Tut-ankh-amon", and "Shakespeare".

The condition of a work of art or museum object may be defined as its physical state at a particular time and with reference to specified environmental conditons, e.g., relative humidity, temperature, light levels. The conservator when called upon to make a condition report to establish whether an object is safe to travel will carry out a detailed examination using various optical and photographic techniques; will refer to previous restoration or conservation documentation; and also to environmental conditions under which the object has been exposed to in the museum. If the object appears to be structurally sound he will want to know about the packing system to be used, method of transportation, and the environmental conditions to be maintained at the borrowing institution. If the latter conditions are inimical to the safety of the object then it will be necessary to specify in the loan agreement such conditions as are considered safe for the ongoing preservation of the object. Thus in preparing the condition report the work of art is examined from the point of view of not only what its present physical state is, but also whether there is a tendency to develop some weakness in structure. In other words to look for fragi-

lity indicators. If the packing and transportation strategy implies little risk in transit, but much risk in the special exhibition gallery, then the condition report will have to include sufficient information and record photographs to refer to in the event that there are structural changes attributable to variations in humidity, temperature, strong light, or pollutants. If on the other hand the greatest risk to be encountered is in transit, the condition report will identify features in the structure likely to be affected by shock, vibration, atmospheric changes in pressure (as in jet air transportation), and variations of temperatures and relative humidity en-route.

To take all possible situations and risks into account the condition report would have to be a very large document with much detailed examination information, data, and supporting photographs. Unless the same conservator travels with the object it will be very difficult to assess any changes in condition. It is well known that conservators may have different views as to the condition of an object. Thus in major international exhibitions there may be several condition reports at different centres (if a "circulating" type of exhibition) representing the visual and technical judgment of different conservators. It is preferable therefore that the conservator of the lending institution be the sole person for preparing the condition report and registering changes in condition at the various venues. If there is a dispute as to condition then a minority report, as an appendix, can be attached as representing the view of the borrowing institution. In the event of an insurance claim for damage, depreciation, or alterations to the work, all of the documents would have to be carefully studied. This could be a complicated affair, particularly in high value loans which may involve considerable claims for depreciation.

It is the experience of most conservators involved in international exhibibitions that the condition reports are generally too brief, and are difficult to use as a sound base for establishing changes. In fact some lending museums simply describe their loans as being in "good condition" arguing that if they were not in good condition they would not be loaned in the first place! It is doubtful that a professional conservator would be a party to this kind of report. There is a tendency to perpetuate this type of "non-reporting" at subsequent centres. The author recalls one travelling exhibition, where the cumulative condition reports had the same entries- "condition good, no change". At the last centre, the conservator prepared a detailed condition report pointing out quite a number of defects which were attributed to transit and exhibition conditions at the previous centres down the line. The first reaction of the authorities (of the lending institution) was to blame the damages on the

last museum. This of course was grossly unfair. It is necessary for there to be consistent standards for condition reports. These must be objective, uncompromising, and sufficiently detailed to avoid misinterpretation, and yet cover all future possible types of damage or deterioration.

Attemps have been made, not always too successful, to devise forms which reports the information in abbreviated form, and oblige the conservator, or other qualified examiner (e.g., curator, or registrar) to cover all the categories. Invariably it is necessary to attach photographs, or sketches, suitably marked, to record some features of condition which could not be noted in the form. Hopefully the photographs have measuring scales, grey scales or (colour standards), so that subsequent examinations for condition can duplicate the photographic setups, to establish any physical changes. It is particularly difficult to determine changes in colour as a result of light exposure, or the extension of crack systems in wood, or canvas supported paintings. The initial photographs may not be sharp enough, or taken under less than favourable conditions so that some of the cracks present are not recorded.

While obvious damages; a tear, break, dent, warping, can be readily recorded photographically, the more subtle changes mentioned can be monitored only with special scientific devices.

In the Irish Treasures Exhibition accurately controlled macro-photographs of pre-selected areas of pages of the Book of Kells manuscripts, and other books were taken initially, and repeated at intervals during the U.S.A. showings. The cumulative effects of light on the selected pages could be assessed to some extent this way. However there are more precise instruments for assessing colour changes on very small areas. Unfortunately it is not possible to transport these to the various exhibition centres. Also to be taken into consideration is the kind of handling required to do these very precise tests.

Not always is curatorial permission given for these types of examination, if there are handling risks involved.

In addition to visual examination and all the various photographic techniques for documenting condition and changes of condition, there are occasions when the weight of the object is of some importance. Thus the exposure of a humidity-sensitive object to variations in climate will alter its equilibrium moisture content. The weighing of objects of wood, parchment, bone, leather, may be useful to confirm that moisture losses (or gains) have given rise to structural changes in condition.

When the object or work of art finally returns to the museum it must be re-examined to establish changes in its state. However a further examination must be made some months later to detect the possibility of delayed action. Ideally the returning object should be returned to a

quiet, environmentally stable environment in the museum (e.g., special storeroom) so as not to confuse the issue by exposing the object to additional environmental changes. Unfortunately the returning object is placed back on exhibition after a brief period and it is not possible to determine with any precision any damage caused by time-delay. Insurance companies are now prepared to consider the possibility of deferred damage. It is certainly of value to study this subject more fully. The efforts of conservators, environmental scientists, and others can contribute to clarifying the nature and duration of structural defects in works of art when they are transported and exhibited in different sites.

81/12/3

TECHNICAL AND CONSERVATION PROGRESS IN EXHIBITIONS IN MEXICAN MUSEUMS

Alejandro Rojas G.

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Care of Works of Art in Transit

TECHNICAL AND CONSERVATION PROGRESS IN EXHIBITIONS IN MEXICAN MUSEUMS

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Summary

Since 1964 there has been a significant growth in museums in Mexico, and a particular emphasis on museological techniques. Various new and adapted buildings are described illustrating the various approaches taken. There has been parallel with this the development of a new type of collaboration among curators, museologists, and restorers. In the organization of permanent and circulating exhibitions the work of the restorer or conservator is very important in ensuring proper conditions of display and handlir

Within recent years there has been much emphasis by the Mexican Government on developing an overall national policy for Mexican museums. Even now we are far from achieving the type of museum which goes beyond the mere collecting of objects. An example of this is to be found in the Museum of Natural History of the University which comprises about 90% gypsum and plaster objects,and in juxtaposition with a small quantity of mannequins. The romantic association with the past is also manifested in the ancient Museum of Geology, also at the University. It is a magni .cent building,

dating to the beginning of the century, and in fact is the first Mexican museum built for the purpose.

1964 marks the turning point in the development of museums as museological institutions. Noteworthy in this regard was the relocation of the Museum of Anthropology from its ancient colonial building (having served its purpose at one time as the Mint) to a new purposeful museum building at Chapultepec Park. It was now possible to think of constructing museums for their unique purposes, collections and public functions, rather than to always think in terms of adaptive use of older structures. Other museums such as the Museum of Modern Art, and the Museum of Natural History in the Park complex were also installed.

The National Museum of Veirreinato at Tepotzotlan may be regarded as a special case of adaption of an older structure, the ex-Jesuit College. In this museum, as in the newly built ones at Chapultepec, the emphasis was on bringing the collections to life, allowing the visitors to be subtly guided through the well-interprete collections. At the end of the visit the public will have had a 'learning and pleasurable experience' .

The new dynamism had its impact in developing various professional categories in the museum. Curators discovered that there was a field called museology. The museologist became aware of the restorer, and had to relate to this person in the organization and conservation of exhibition materials on view. The newer museum included these various persons, each skilled in their own fields, yet overlapping into each other's discipline. The restorer (or conservator) is often called upon to advise on the safe methods to be used for display, apart from his usual work of restoration and identification. Archeologists and restorers have had good contacts regarding the preparation of objects for display. Often the accretions hide important designs which can only be removed by skilled hands. The conservation of objects and works of art on exhibition and in transit is increasingly recognized as an important task for the restorer.

Exhibition technology is therefore an important part of the overall museum activity. The intention is to bring more works of art and cultural objects to the public, through exhibitions, and travel, and at the same time to develop the necessary museological and conservation techniques.

Examples will be shown of the museological approaches in the forementioned museums and the conservation measures for permanent and circulating exhibitions.

81/12/4

REPORT ON 'THE INTERNATIONAL ART EXHIBITION ORGANISER'S MANUAL'

P. Cannon-Brookes

ICOM Committee for Conservation
6th Triennial Meeting
Ottawa 1981

Working Group: Care of Works of Art
in Transit

REPORT ON 'THE INTERNATIONAL ART EXHIBITION ORGANISER'S MANUAL'

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Summary

Begun in 1977 as a joint project of the Conservation and International Art Exhibitions Committees of ICOM, the International Art Exhibition Organiser's Manual provides, for the first time, a code of practice setting out what a lender to an exhibition can expect to happen to his loan. The Manual thus gives practical embodiment to the statement of intent provided by the ICOM Guidelines for Loans published in 1974 and makes available a convenient corpus of exhibition organising practice to be cited in agreements to lend and insurance contracts. The basic strategy throughout is the reduction of wear and tear to a minimum with, where possible, the elimination of avoidable hazards, and the report summarises the principles adopted by the authors.

All conservators are only too aware of the wildly differing 'house styles' adopted by museums and art galleries, so that the standard practice of one is ignored by another and customs which are tolerated in some as 'realistic' are outlawed in the rest. Curators and conservators are united over the need for standards, not least in the organisation and administration of temporary exhibitions, but few have made any attempt to establish codes of practice which bridge the gap between conservation theory and curatorial practice. The vast increase in the number and scale of the temporary exhibitions organised since the Second World War has, mercifully, been accompanied by a much greater awareness of the causes of deterioration in works of art and the strategies which can be evolved to reduce the rate of deterioration to a minimum. In establishing codes of practice to govern the loan of works of art to temporary exhibitions it is essential that they are formulated with direct reference to actual experience since vague expressions of goodwill, unrelated to defined conditions and practices, are of dubious significance and may be positively misleading.

Two fundamental principles apply throughout, in that no work of art made of organic materials can be transported and displayed in the new environment of an exhibition without increasing the rate of deterioration of those materials, no matter how small that increase can be made by skilled handling and carefully controlled environmental conditions throughout, while, paradoxically, there is virtually nothing which cannot be transported and displayed in an exhibition, with an acceptable degree of safety, if sufficient resources are assigned to the task. Provided the risks and increased rate of deterioration are reduced to a minimum, the problem becomes one of commensurability, and the decision to lend will depend upon a rigorous assessment as to whether the increased rate of deterioration likely to be experienced and the hazards are commensurate with the positive gains to be made.

Authoritative specifications for packing and transportation have been available for many years, and they are constantly being refined as new challenges are met, but the general adoption of improved standards by exhibition organisers has been much slower. A considerable advance was made when the ICOM Guidelines for Loans was adopted as official Unesco policy, but these guidelines were always understood to be only a statement of intent, providing the skeleton to which would be added in due course the flesh and muscles of carefully formulated codes of practice. In this work the Conservation Committee of ICOM has worked in close cooperation with the former International Art Exhibitions Committee, and although the latter ceased to exist in 1980, the Guidelines were formulated by one of its working groups and the initiative came from it.

The International Art Exhibition Organiser's Manual, prepared by Dr. Nathan Stolow and the present author, provides a code of practice for the organisation and administration of temporary exhibitions. It does not pretend to be either a comprehensive do-it-yourself manual for would-be exhibition organisers, or a bible providing authoritative guidance for every eventuality, but a code of practice for the organisation and administration of temporary exhibitions whereby, for the first time, both lenders and borrowers have a clear idea of their respective rights and responsibilities unless other provisions are specifically agreed during the negotiation of a loan. Thus, to the non-specialist, the Manual provides a code of practice governing what the lender to an exhibition can expect to happen to his loan, without further consultation, and what is unacceptable or requires special authority. Consequently the Manual makes available a convenient and readily accessible corpus of exhibition organising practice in printed form so that a lender can agree to the loan of a work of art "subject to the provisions of the International Art Exhibition Organiser's Manual, except in those respects mutually agreed in writing during the negotiations for the loan", and then be able to rest assured that he has in fact insisted upon standards which have been subjected to exhaustive technical scrutiny.

Furthermore, apart from the obvious protection afforded to Trustees and the legal advisors of lenders, the definition of standards for

the organisation and administration of temporary exhibitions is intended to enable insurers to differentiate between good and bad practice, and to penalise bad practice through higher premium rates. This is of particular importance to fine art transporters who, through the efforts of ICEFAT (the International Convention of Exhibition and Fine Art Transporters), are attempting to, in their own words, "perform up to a standard, and not down to a price". In normal commercial and industrial operations risk management is a standard procedure, but its full introduction into temporary exhibitions has been delayed by the absence of any international code of practice to which reference can be made in the formulation of insurance contracts. Similarly, the fine art transporters are unable to make meaningful competitive quotations for packing and transportation if the standards to be adopted remain undefined.

In an exhibition budget, the environmental control of the exhibition and the specifications for packing and transportation are two elements which are not immediately subjected to critical scrutiny, if nothing is seen to go wrong. Risks are taken, or in ignorance remain unrecognised, and the full consequences of reckless or incompetent planning are inflicted on the unfortunate lender, sometimes months or years after the loan has been returned and the trail has become cold. Instead, the Manual demands of all art exhibition organisers a clarity of thought and a precision of strategic objectives not always found today. A clear statement of intent was made as early as 1936 by E. Foundoukis, Secretary General of the International Museums Office, in his gloss to the text of the Recommendations of the Assembly of the League of Nations regarding the Organisation of International Art Exhibitions, adopted at its 17th Session, when he stated "In view of the risks involved in moving unique and irreplaceable works of art, it is necessary to consider to what extent the educational and scientific value of these temporary loans really outweighs the dangers incurred", and "In attempting to harmonise the interests of conservation with the educational and scientific role of works of art, conservation must be taken as the starting point".

Thus the principle of commensurability is implicit in both the ICOM Guidelines for Loans and the earlier League of Nations statements, but its establishment as a primary consideration is dependent upon a quantification, or at least assessment, of the hazards and the increased wear and tear to which the loan is to be exposed as a result of the systems of packing, transportation and display selected by the exhibition organiser. Commensurability is a yardstick employed throughout the Manual, and thus the evolution of the Transportation Strategy by which the often conflicting demands of high security, effective conservation and low cost are reconciled. The technique of packing will depend upon the means of transportation to be adopted and whether an escort is to be employed. Apart from improved security, leading to lower insurance premium rates, further economies can be achieved as a consequence of the smaller size of packages required when escorts are employed. Despite the cost of employing escorts the total expenditure can in fact be lower, and the major

museums' insistence upon the use of escorts as a condition of loan is not merely an unnecessary extravagance and an avoidable cause of increased costs.

However there is no useful purpose in sending an escort or courier who has not been properly trained to carry out what is often a very demanding role, or who travels unprepared. This is an important area of close cooperation between conservators and curators, and the Manual stresses the central role played by curators and conservators in the complex interplay of functions of the other specialists active in the organisation and administration of temporary exhibitions, as well as in the evolution of strategies designed to reduce the wear and tear on the loans to a minimum.

In developing, as a logical progression wherever possible, the stages of the organisation of a temporary exhibition, the Manual establishes codes of practice for each operation, from the formulation of the intellectual basis of the proposed exhibition and the selection of possible exhibits to the long-term liabilities of the exhibition organiser many months after it has closed and the exhibits have been returned to the lenders. Of particular significance to the Working Group on the Transportation of Works of Art is the evolution of recommended codes of practice for packing and transportation, derived from a process of distillation of traditional techniques and sophistocated modern methods, and their application as integral parts of the total operation. This high degree of integration has important implications for all museum activities in that, with the exception of acquisitions and long-term storage, the temporary exhibition provides us with a microcosm of virtually the whole museum operation. The lessons to be learnt are self-evident, and it is to be hoped that the publication of the Manual will have a beneficial effect over a much wider spectrum of museum activities.

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NATURAL HISTORY COLLECTIONS

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